Vol. XLIX **TABLE OF CONTENTS.** No. 3

(24 pages; no inset.)

	Page
ENGINEERING NEWS OF THE WEEK	45
LEADING ARTICLES:	
The Rutland-Canadian Ry. and Its Structures (illustrated).....John W. Burke.	46
Agricultural Engineering .....Elwood Mead, M. Am. Soc. C. E.	49
Rules for Working Loads of Wire Elevator Ropes (illustrated)..... H. C. Newcomer, Captain, Corps of Engineers, U. S. A.	50
Proposed Retaining Barriers for the Débris from Hydraulic Mining in the Yuba River, Cal. (illustrated)	52
Coking in Bee-Hive Ovens with Reference to Yield....Charles Catlett, M. Am. Inst. M. E.	53
A Sewage Sludge Reduction Plant at Cassel, Germany (illustrated)	54
Concrete-Mixing and Handling Machines for the Galveston Sea-Wall (illustrated).....	55
A Water Supply for Hydraulic Mining at the Briseis Tin Mines, Tasmania.....	55
The Cost of Crushing Stone at Baraboo, Wis.....W. G. Kirchoffer, C. E.	55
Governor Odell on the Proposed 1,000-Ton Barge Canal	60
A New Automatic Oil-Switch for High-Tension Circuits (illustrated)	61
An Electric Speed Controller Attachment to a Water-Wheel Governor	62
The Organization for Construction of the Pennsylvania R. R. Extension in New York City..	62
Forestry on Water-Works Drainage Areas.....	62
The Elimination of Hand Labor in Brick-Making (illustrated)....J. Parker B. Fiske, S. B.	63
Fundamental Differences in the Construction of Gas and Steam Engines..... P. Plantinga, M. Am. Soc. M. E.	67
EDITORIAL COMMENT.—Eliminating Hand Labor in Brick Manufacture—Gov. Odell's Attitude Toward the Proposed 1,000-Ton Barge Canal—The Wanstead Collision and Its Lessons—Safe Loads for Wire Elevator Ropes.....	56
EDITORIAL.—The Resistance to Traction of Small Mine Cars.....	57
LETTERS TO THE EDITOR.—The Compensation of Engineers: J. I. Boggs—The Inefficiency of Joist Hangers of the Stirrup Type (illustrated): F. E. Kidder—Ration Lists for U. S. Geological Survey Parties: H. M. Wilson—An Answer to Some Anti-Metric Arguments: W. C. Hammatt, M. Am. Soc. C. E.—From a Metric Advocate: Arthur Lagron, C. E.—Experience with the Metric System in Mexico: A. S. Robinson—Concerning Systems of Measurement: Ernest McCullough—Notes and Queries 57-60	

THE IMPROVEMENT OF THE CHICAGO RIVER is planned by the Sanitary District, and Mr. Isham Randolph, the Chief Engineer, has made an estimate of the cost of the work to be done during 1903 and 1904. This aggregates about $4,700,000, in addition to which the development of the water power at Lockport and Joliet will cost about $2 500,000. The estimate for the river work is as follows:

Dredging and docking	$2,154,884
New bridges	1,932,424
Improvement of the North Branch	185,000
Miscellaneous (mainly for pumping plant, etc., for the 39th St. conduit)	432,900
Total	$4,703,208

NEW VESSELS FOR THE GREAT LAKES to the number of 62 are being built. Of these 39 are for the U. S. Steel Corporation. The aggregate value of these 62 boats is $13,491,500.

NEW YORK CANALS carried 3,274,446 tons of freight in 1902, a falling off of 146,167 tons from the record of 1901. The falling off in traffic was in through freight, the total reduction in this class being 210,600 tons. The falling off is believed to have been chiefly due to the coal strike. The total cost of maintenance and repairs for 1902 was as follows:

Maintenance and ordinary repairs	$931,051
Extraordinary repairs	262,684

It will be seen from these figures that the taxpayers of the state contributed about a third of a dollar toward the cost of carrying every ton of freight moved on the canals.

THE COMMERCE OF THE GREAT LAKES for 1902 is noted by the U. S. Bureau of Statistics. The record is actually for the eleven months ending with November, but the December tonnage does not materially change the total, as the season of through navigation closed with the preceding month. The arrivals at ports on the lakes for the eleven months numbered 77,408 vessels, with a net registered tonnage of 71,443,517 net tons; there were 77,899 clearances from these ports representing 72,215,099 net tons. These figures do not include tonnage employed in the lake trade between Canada and the United States. Twenty separate ports on the lakes have each a registered tonnage of arrivals ranging from 1,000,000 to 5,000,000 tons; four ports on Lake Superior have a combined tonnage of 14,353,972 net tons, of which Duluth is credited with 4,971,434 tons. The enormous volume of lake tonnage is better appreciated when it is noted that the port of New York is only credited with 8,982,767 registered tons of arrivals in 1902, and London in 1901 had entrances amounting to 9,992,753 tons.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Pennsylvania R. R. at Duquesne, Pa., on Jan. 7. An accommodation train, southbound from Pittsburg, struck the rear end of a freight train which had not fully made its siding. Three trainmen and four passengers were either killed outright or burned to death in the fire that followed the crash; a dozen or more others were injured. The accident is said to be chargeable to the rear brakeman of the freight, who failed to clear the rear end of his train.——An accident quite as unusual as the preceding occurred on the following day, Jan. 8, on another part of the Pennsylvania system. A fast passenger train ran into the rear of an accommodation train at Ada, O., and crushed the two rear cars of the accommodation. Three persons were killed and ten or more injured. It is stated that the collision came about because the forward train was forced to stop on the open track and the flagman sent back to signal the following train was not seen by the engineer on account of a driving snowstorm.

THE GRAND TRUNK RAILWAY ACCIDENT, noted in our issue of last week, a butting collision near St. Catherine's, Ont., should be charged to an error in train despatching instead of to a mistake of the engine driver, as was reported in our note of the accident. It appears that the regular train, which was behind time, received orders to run twenty minutes late, while the orders issued to the light engine (which later collided with this train) said that the train would run forty minutes late.

A PECULIAR ACCIDENT OCCURRED recently on the Hannibal & St. Joseph R. R., at Yellow Creek, Mo. A wreck had occurred on the line, and a wrecking train, at the head of which was a derrick car pushed by an engine, was being hurried to the spot. The boom of the derrick happened to project too far and when the train reached a through bridge at Yellow Creek the boom caught in the upper laterals of the bridge and tore them away. The weight of the engine, immediately behind the wrecker, was too great for the weakened bridge, and it gave way, dropping the engine and several cars into the channel below. Two men were killed in the fall. We are indebted for our information to Mr. L. C. Heydrick, of Mapleton, Missouri.

DIGGING DYNAMITE OUT OF A MISFIRED HOLE by means of an iron rod resulted in an explosion at 183d St., New York, on Jan. 9. The iron rod was driven into the neck of the man engaged in removing the charge, but by good luck missed any vital spot and his recovery is said to be possible.

SULPHUR AND ARSENIC FUMES from the smelters near Butte, Mont., have injured the agricultural industries to such an extent that farmers have held mass meetings to take legal action. Five tons of sulphuric acid and 2½ tons of arsenic are daily discharged into the air by these smelters, it is said.

CALIFORNIA'S GOLD YIELD for last year is estimated at $18,000,000 which is an increase of $1,000,000 over 1901. The introduction of electric power has aided greatly in the increased gold production.

THE CHAMPION IRON MINE HAS BEEN SOLD to the Clairton Steel Co., of Pittsburg, for about $2,000,000. The Champion Mine is located in northern Michigan, and was one of the great producers until the Mesabi ores were exploited. It has produced almost four million tons and its annual output now is about 135,000 tons.

NEW IRON, COAL, OIL AND GAS FIELDS in Montana have been discovered. In Chateau county a coal outcropping averaging 4 ft. thick and 1½ miles long has been found and a company incorporated to develop it. In Butcher Creek Valley oil has been struck at a depth of 300 to 400 ft. by the Cruse Oil Co. of Helena. Two miles west of Livingston a natural gas well is yielding excellent gas in great quantity, and there is a rush of prospectors and speculators to that section. Red hematite (65% iron) ore is said to exist in great quantities 12 miles west of Missoula.

BY-PRODUCT COKE OVENS are steadily increasing in number. Every one of the following six companies has increased or is increasing the number of ovens, and when those under way are finished the total will be 1,310 by-product ovens, distributed thus: Cambria Steel Co., 260; Riverside (Wheeling, W. Va.), 120; Ensley, Ala., 240; Dunbar, Pa., 110; Dominion Iron & Steel Co., 600; Nova Scotia Steel, 80.

THE COPPER SANDS OR TAILINGS are being worked over at the old Franklin (Mich.) mill, and a concentrating plant for a similar purpose is being built at the Central Mine. All of which goes to emphasize the fact that it will generally pay to save all mill tailings for the day that will eventually come when they may be profitably worked over.

THE REMOVAL OF THE CROTON AQUEDUCT Commission is requested by a committee of the Merchants' Association of New York city at the conclusion of a long communication to Mayor Low. The committee charges the commission, as constituted on July 15, 1902, "with neglect and malfeasance both in respect of the New Croton Dam and the Jerome Park Reservoir." As to the dam, the committee alleges that the commission failed to fix a time limit when ordering radical changes; that it improperly allowed road-making work to be charged up at the contract prices for "earth and rock excavation of a distinct and very much more different character"; and that it has neglected to have "work performed that is necessary to be done before the dam can be effective." In the matter of the Jerome Park Reservoir the committee alleged that the commission approved wholly unnecessary and expensive changes in the original plan; that in calling in expert engineers to report on changes it failed to bring some of the changes to the attention of the committee; and that subsequently one of the experts, instead of all three, was invited by the chief engineer to make a further report, and that notwithstanding the advice of the experts, changes in the original plan have been continued. Other changes alleged to have been unwarranted pertain to the great gate-house, and on these an adverse opinion has been rendered to the committee by Mr. F. P. Stearns, M. Am. Soc. C. E., Chief Engineer of the Metropolitan Water and Sewerage Board. Mr. Stearns is quoted as stating that the changes in the gate house "made by the later plans have resulted in a somewhat decreased efficiency and greatly increased cost." Besides Mr. Stearns' report, the communication to the Mayor is accompanied by letters from Mr. Alfred Craven, M. Am. Soc. C. E., formerly division engineer in charge of the Jerome Park Reservoir, containing figures designed to show how the changes in the reservoir increased its cost.

THE LONGEST FLUME IN THE WORLD, at Madera, Cal., is finished. It is 63 miles long, and has in addition 18 miles of feeders. The flume is V-shaped, 46 ins. across the top and 36-in. sides. The cost was $270,000. It runs through the heart of the redwood forest, 185 miles from San Francisco, and will carry 400,000 ft. B. M. of logs daily when run to its full capacity.

ELECTRO-PNEUMATIC TRAIN CONTROL has been adopted on the Brooklyn elevated railway lines after a long-time service test of different methods of multiple-unit train control. This system involves the use of compressed air for moving the current-controlling apparatus, the air supply being obtained from the train air-brake pipe. The admission of the air to the operating mechanism is controlled by valves opened or closed by electro-magnets. The latter are energized by current from a series of low-voltage circuits connecting the different cars of a train. The connection of these low-voltage circuits is the only one that must be made, in addition to the brake-hose connection, when the cars are coupled up. Each car in the train is an isolated unit as far as the main power circuit is concerned. Some interesting peculiarities are inherent in the electro-pneumatic system of train control: When the brakes are applied (by reduction of the train-pipe pressure) the power is automatically turned off on all cars of the train. When the train breaks in two the power is turned off and the brakes applied on each car, by the escape of air from the train-pipe. In these features of safety the system follows the same principles as the well-known Westinghouse automatic air-brake. A further feature of the electro-pneumatic train control is that in case the low-voltage control circuit fails, the train may be stopped by means of the regular brake valve. Moreover, the controllers on the different cars may in case of emergency be operated by hand. This system was worked out by Mr. George Westinghouse, and the equipment for it will be supplied to the Brooklyn elevated lines by the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa.

THE RUTLAND-CANADIAN RAILWAY AND ITS STRUCTURES.

By John W. Burke.*

The Rutland-Canadian railway from Burlington, Vt., to Rouse's Point, N. Y., 41 miles, is part of the Rutland R. R. system and connects the Rutland Division ending at Burlington with the Ogdensburg & Lake Champlain Division ending at Rouse's Point, making the Rutland line continuous from Bellows Falls to Ogdensburg, 279 miles, via Rutland, Burlington and Rouse's Point. At Ogdensburg connection is made with the steamers of the Rutland Transit Co., controlled by the Rutland R. R. Co., to and from Chicago, Duluth and other Lake ports. At Bellows Falls connection is made with the Boston & Maine for Boston and lower New England points. The New York connection is made over the Bennington & Rutland Division, recently bought by the Rutland, and via the New York Central & Hudson River R. R. from Troy. The Rutland-Canadian also includes a line from Alburg, Vt., to Noyan, P. Q., 6 miles, where it connects with the Quebec Southern and the Canada-Atlantic railways. Through the Quebec Southern Ry., from Noyan, connections are made for Sorel and Quebec. The Canada-Atlantic extends to Ottawa and to Parry Sound on Georgian Bay. The Rutland R. R. also has running powers over the Canadian Pacific Ry. into Montreal, so that its passenger trains are run with its own crews between Troy and Montreal. The Rutland-Canadian road afforded the Rutland R. R. all these Northern connections.

Burlington is on the east shore of Lake Champlain and Alburg is at the north end of the lake. The new road between these points is nearly an air line, built on the large islands in the middle of Lake Champlain. The distance between these points on the new road is 37 miles, as compared with the distance of 52 miles on the Central Vermont Ry., which is located on the main land near the lake shore. The maximum curvature outside of yard limits is 1° 30'. The maximum grade going south, the direction of heavier traffic, is 0.57%, and going north, the direction of lighter traffic, is 0.70%. The ratio of curve to total distance outside of yard limits is 26.8%, and the total angularity outside of terminal yard limits is 272° to the right and 237° to the left. The track is of 80 lbs. steel rails and is mostly rock ballasted.

BRIDGES AND CULVERTS.—The bridges are of acid open-hearth steel designed to carry two 142-ton consolidated locomotives followed by a uniform load of 4,000 lbs. per foot on draw spans and 4,200 lbs. on fixed spans. The bridge masonry is of heavy limestone ashlar laid in Portland cement and founded on cribs filled with Portland cement concrete, and resting on piles or on rock bottom and heavily riprapped. At the Winooski River crossing there are three 150-ft. through riveted lattice steel spans, each weighing about 138 net tons, founded on ashlar on concrete cribs supported by piles driven into silty sand. Near the south end of the lake embankment at Colchester Point there is an 86 ft. girder span on foundation similar to the above. At each of the three lake crossings there is a through riveted lattice pivot draw span 196 ft. 8 ins. long, and weighing, exclusive of operating machinery and castings, about 192 net tons. The operating mechanism is so designed that the moving of the end rollers, the track rails, and the latches is done by one operation, either at each end of the bridge independent of the other end or at both ends simultaneously from the center of the bridge. Home and distant signals are also operated from the center of the bridge. The bridge and signal mechanisms interlock. The distance from top of pivot pier masonry to base of rail is only 5 ft., and all the machinery is contained within this height. These draws (Fig. 1) are center bearing to facilitate turning, but rim bearing as long as they support moving loads. The trusses are 16 ft. 6 ins. apart c. to c., and have a panel of the same length over the pivot pier, so that the floor beams at these points together with the middle panels of the lower chord form a square box, 16½ ft. on each side, upon the corners of which all the load is borne. This box rests at eight equidistant points upon the wheel circle, which is 18 ft. 8 ins. in diameter, and to which all load on the pier is carried through the lower chord and center floor beams, acting as cantilevers. The usual drum is dispensed with and the upper wheel track is fastened directly to the under side of the chord and center floor beams, these being bracketed out to give firm support where the wheel circle passes outside of them. The bridge is so adjusted by means of the four large adjusting screws at the pivot that when there is no moving load on the span it barely touches the wheels and practically all of the weight is carried by the pivot, the wheels serving only as guides. But when a train comes on the bridge, inasmuch as all the load which passes to the center pier must come through the four corners of the box before spoken of, the corners of this box will be depressed, thus throwing all of this additional load on the wheels and correspondingly relieving the pressure on the pivot.

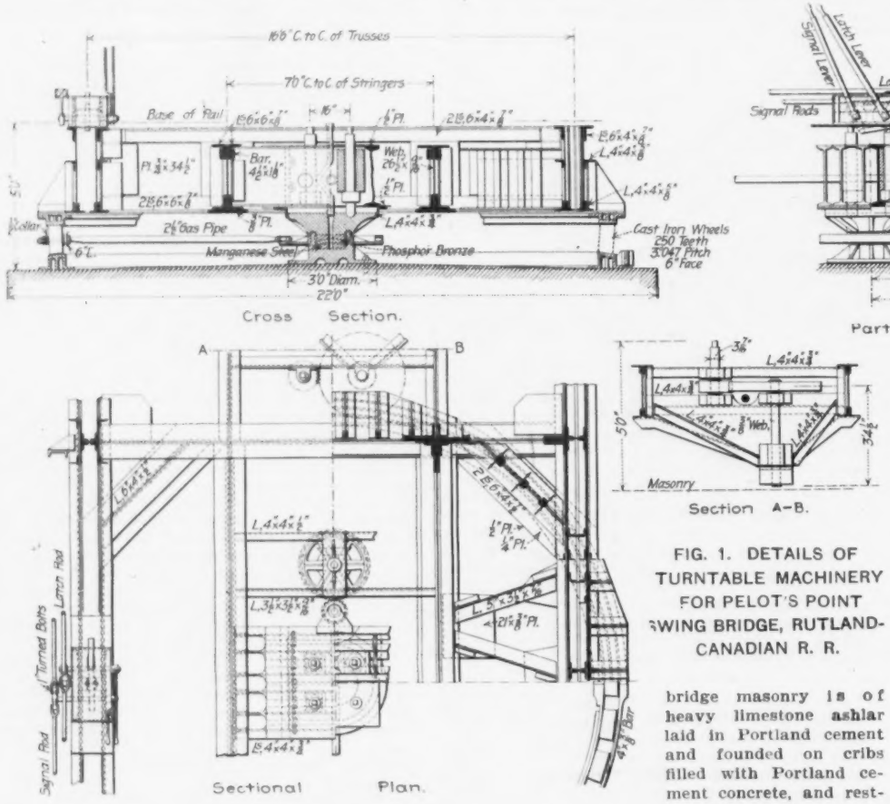


FIG. 1. DETAILS OF TURNTABLE MACHINERY FOR PELOT'S POINT SWING BRIDGE, RUTLAND-CANADIAN R. R.

The ends of the bridge are supported by rollers which are raised and lowered by means of a rack and pinion movement operating a toggle joint, a device giving the greatest power at the point where it is most needed, namely when pushing the rollers into place and starting them for drawing. The rollers are not intended to lift the ends of the bridge but only to bring them to a bearing and are so adjusted that they merely come to a firm bearing when the bridge is in place and exert no appreciable lifting force. The trusses are fully continuous over the pier and there is no "kicking" of the ends under any circumstances. The rollers are made to operate lengthwise of the bridge and not crosswise as is frequently the case, thus providing full facility for expansion and contraction.

The rails at the ends of the bridge are raised and lowered by means of a cam device working simultaneously with the end rollers and so arranged as not only to let the rails down in their sockets but hold them there firmly, so that there is no rattling of the loose end rails so often noticed on draw spans under moving trains.

The locking is accomplished by a heavy vertical bolt, dropping into a socket on the abutment. This bolt is counterweighted so that it can be raised with any desired degree of ease or speed. After the bridge has been opened this bolt can be

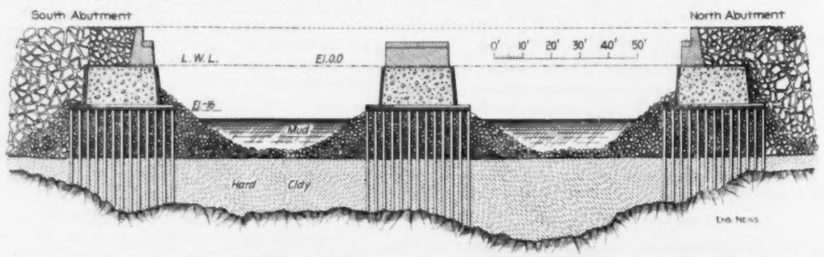


FIG. 2. LONGITUDINAL SECTIONAL ELEVATION OF FOUNDATIONS FOR PELOT'S POINT SWING BRIDGE, RUTLAND-CANADIAN R. R.

*Chief Engineer, Champlain Construction Co.; Civil Engineer, 45 Broadway, New York.

released and dropped so that it will enter its socket automatically when this is reached. The lower end of the bolt is furnished with a roller and the upper parts of the socket are rounded so that this roller will ride up on them and drop into the socket. The bolt is weighted so that its motion is rather slow. Consequently, if the bridge is turning slowly, as it should, the bolt will fall into the socket at the proper time and hold the structure, but if it is moving rapidly then the roller will ride over the socket and thus avoid bringing up the great mass with a sudden shock and possibly damaging the structure.

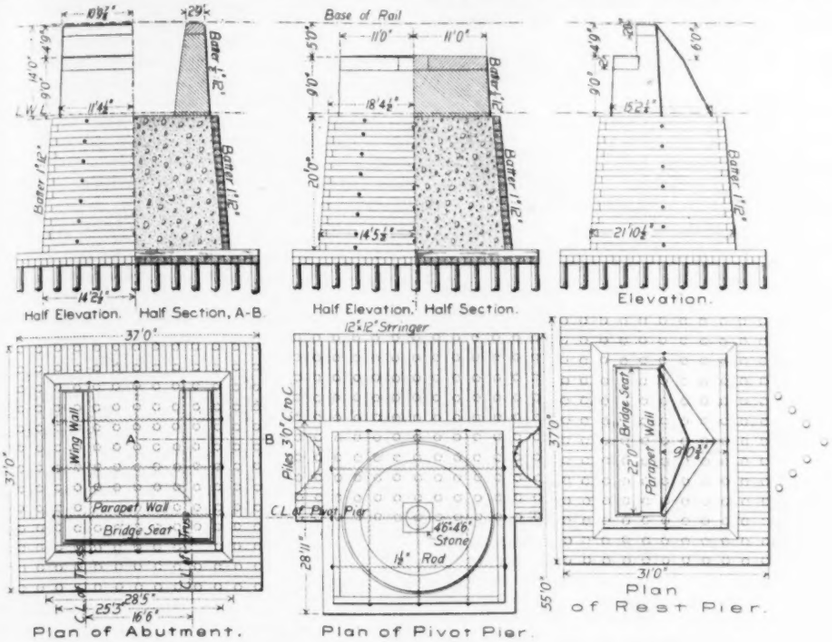


FIG. 3. DETAILS OF SUBSTRUCTURE FOR PELOT'S POINT SWING BRIDGE.

All of the operations of setting the signals, drawing the bolts, releasing the end rollers and swinging the bridge are so interlocked that it is impossible to perform them except in the required order. When the bridge is closed and ready for crossing with the signal set at safety, the only thing that can be moved is the signal rod. As soon as the signal is moved to danger the bolts are unlocked and can be lifted from their sockets. That operation unlocks the end roller machinery making it possible to release the ends of the bridge, while at the same time the signal is locked at danger and cannot be moved back to safety until the end rollers are again in place and the bolts in their sockets. After the end rollers are drawn, then and not till then the bridge can be swung, and each operation locks the preceding one as it is performed so that they can only be reversed in the same order except that it is possible to release the bolts while the bridge is open so that they may drop into their sockets as the bridge swings around. There is no possible way by which the safety signal can again be displayed until the bridge is swung back in position for crossing, the end rollers in place, and the bridge held by the latching bolts. And when the safety signal is again set it is impossible to move any of the rest of the machinery.

Another feature in these bridges which is believed to be peculiar to them is the method adopted for adjusting the heights of the ends of the spans. Ordinarily a somewhat tedious computation is made to ascertain how much the ends of the bridge may be expected to drop, and the chords are lengthened and shortened accordingly to bring the ends to a level when swinging free. This is not a very satisfactory proceeding, for the actual deflection of the arms rarely corresponds to that calculated and not infrequently there is slightly different deflection in all four of the arms. In these bridges the adjustment of the ends to the required height is accomplished in another and much simpler manner. The lower chords are cut in two just outside of the center panel and the ends of the chords brought together with a butt joint, which is bolted. After the trusses are riveted up and the ties and rails laid, the end blocking is removed and the ends allowed to take such deflection as they will. The bolts are then removed from the butt joints in the chords and all four ends are jacked up until they are exactly at the same level when thin plates are inserted in the open joints of the chords to hold them in this position and the chords then riveted up, thus easily and quickly adjusting the ends to exactly the same height. The actual height of the ends, within limits, is of small importance but it is essential to perfect operation that they should all be of the same height.

These bridges are about the extreme limit of size and weight possible for operation by hand power within reasonable time limits. The drawbridges have circular pivot piers and U-abutments, leaving a clear waterway of 80 ft. The ashlar rests on wooden cribs filled with concrete. The abutment cribs also have oblique rubble-filled wings to receive the toe of the rubble embankment in the lake. The subfoundation of the Allen's Point drawbridge is of piles driven into very fine sand; of the drawbridge at the "Gut," ledge rock and hard pan dredged and leveled with rubble to receive the concrete cribs; of the Pelot's Point drawbridge, (Fig. 2) piles driven through mud and through a substratum of hard clay to ledge rock, which was roughened and partly stepped by sub-aqueous blasting, the entire area between abutments, pivot and rest piers being riprapped to a depth of 3 to 7 ft. At drawbridge No. 3, Pelot's Point, the water is about 23 ft. deep. The lake bottom at this place consists of about 15 ft. of viscous mud underlaid with 10 to 20 ft. of stiff clay immediately over the bed rock. The foundation adopted consisted of piles driven to rock, sawn off just above the mud and bearing wooden cribs filled with concrete to near low water mark, and ashlar masonry from there up (Fig. 3). Portions of the surface of the rock at the sites of the two abutments had a slope of about 25%. These portions of the rock surface were thoroughly roughened (Fig. 2) and made somewhat less sloping by sub-aqueous blasting with heavy charges of 70% dynamite, the holes being about 3½ ins. in diameter, 4 to 8 ft. deep, and 6 ft. apart, and about half filled with the explosive. The 24-in. bottoms of the cribs were extended out beyond the side wall of the cribs to make a greater bearing surface, the additional piles to support them affording increased lateral stability, which was further increased by dumping rubble about 4 ft. deep between the tops of the piles, and also by forming a continuous riprap of rubble between the pivot pier and both abutments. Mr. H. W. Brinckerhoff, M. Am. Soc. C. E., and Mr. Thomas F. Chappell were consulting engineers on the foundations for this bridge.

Besides the bridges for permanent way, which have been described, a number of bridges were built to carry highways and farm roads over the railway. Some of these overhead highway bridges were steel structures and others were steel timber structures. Fig. 4 gives the details of one of the steel bridges having a span of 21 ft. 9 in., the drawing being so complete that no further description is necessary. Fig. 5 gives the details of one of the temporary wooden bridges erected pending the delivery of the steel bridges.

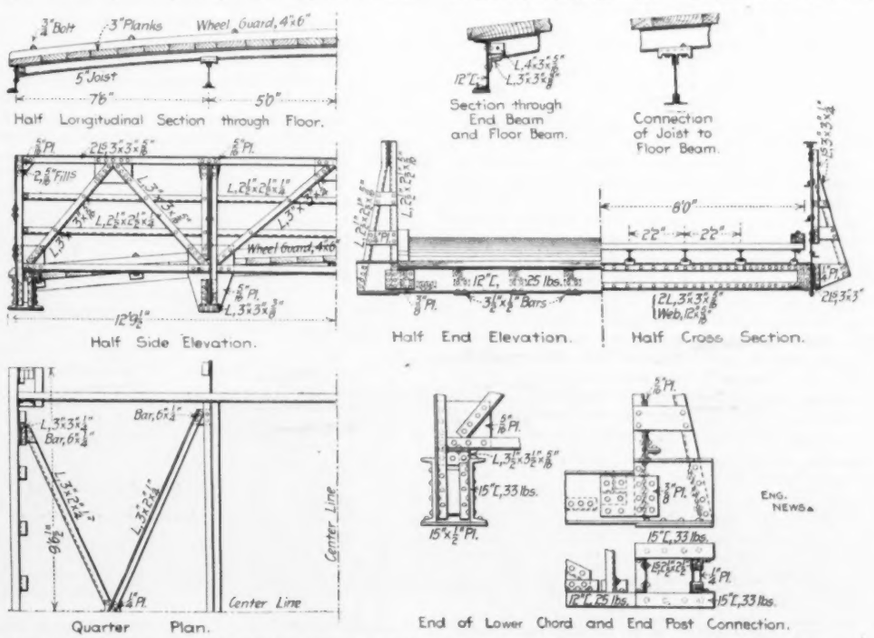

Half Longitudinal Section through Floor.
Half Side Elevation.
Half End Elevation.
Half Cross Section.
Section through End Beam and Floor Beam.
Connection of Joist to Floor Beam.
Quarter Plan.
End of Lower Chord and End Post Connection.
Wheel Guard, 4"x6"
Center Line
ENG. NEWS

FIG. 4. DETAILS OF OVERHEAD STEEL HIGHWAY BRIDGE, RUTLAND-CANADIAN R. R.

Except at bridges there are no openings in the tracks, all cattle passes (Fig. 6), culverts (Fig. 7) and drains being covered, and the cattle guards (Fig. 8) being of the surface type. All culverts

and cattle passes are stone box. The watershed on the islands is small, and only one arch culvert was built. The stone for bridge masonry came from a limestone quarry opened by the railway company on South Hero Island, and to which quarry a spur track two miles long was laid. This stone in blocks of from 1 to 5 cu yds. was used for the outer slopes of the rubble embankments in the lake.

LAKE EMBANKMENTS—The most noteworthy features of the construction are the lake embankments (Fig. 9). Of these there are three: No. 1 from the mainland at Colchester Point to South Hero Island at Allen's Point, 3.24 miles; No. 2 from South Hero Island at Tromp's Point to North Hero Island at Bow Arrow Point, 0.5 mile; and No. 3 from North Hero Island at Pelot's Point to the mainland at Alburg Tongue, 0.83 mile. These lake embankments are built of rubble dumped from a temporary trestle. Standard gage, single-truck side dumps were used. Except for the small amount of material obtained from the through cuts for the roadbed approaching the lake shore, the rubble for these embankments came from side face borrow pits opened on the low bluffs along the lake shore adjacent to the roadbed and near the ends of the lake embankments. The face of the borrow pit averaged about 18 ft. The explosive used was 40% dynamite, or black powder, depending on the character and dip of the rock. Some Judson powder also was used, but the explosive was generally 40% dynamite. The material blasted was loaded into cars by steam shovel. The rubble embankments are 15 ft. wide at sub-grade and have an average slope of about 1.3 horizontal to 1 vertical. Where the core was built of larger stone or where the heavy stone for exterior slopes were promptly placed the embankment took a slope of about 1 on 1.1, except near the surface of the water, where in all cases the wave action produced a slope of about 1 on 1.7, forming a small berm in the embankment. Sub-grade is at an elevation of 12 ft. above low water mark. The range of the lake is about 7 ft. The grade is made 0.5 ft. higher at the lake bridges, elevation of base of rail on these bridges being 13.5. Following is an extract from part of the clauses on rubble embankments in the specifications:

> The lake crossings will be made with rubble-stone embankment, having drawbridge openings where designated. The material for these embankments will be obtained principally from the rock cuts for the roadbed near these crossings and by widening these cuts. The interior portion of these embankments shall be made of stone of such sizes as naturally blast out of these cuts, except that no stone shall be less than ½ cu. ft. in capacity and the average size for this interior filling shall not be less than 1 cu. ft. in capacity. Sound field stone of these sizes may be used in the interior filling. The small fragments produced by quarrying may also be deposited in the interior part of the embankment at the written order of the chief engineer, or at his direction it shall be delivered onto the roadbed by the contractor for ballasting. If thus used for ballast it may at the discretion of the company be crushed or broken to a suitable size at the company's expense and then taken by the contractor for ballasting as from a ballast pit. The exterior slopes of the embankments for a thickness of not less than 4 ft. into the body of the embankment at its base, and 3 ft. at its top, shall be of sound rubble stone dumped into place so as to make a general slope of one to one, as shown on plans and as directed by the engineer. The blocks for this exterior portion on the lake side of the embankment shall be not less than 15 cu. ft. in contents each, and the average contents of each block shall be not less than 22 cu. ft. On the bay side of the embankment the sizes of the blocks in the exterior portions shall be not less than 10 cu. ft. and average not less than 15 cu. ft. each. The exterior portions shall be carried up simultaneously with the interior portions so as to bond them together.

The rubble embankments were designed and their grade established after a few weeks' study of the wave action at different places on Lake Champlain, and after enquiries among the United States Engineer Officers, skippers, boatmen and farmers long familiar with that lake. These opinions, of course, varied, but the general consensus was that at the proposed sites for these embankments the maximum wave height is about 5½ ft. from trough to crest. Observation during construction confirms this estimate. The only other criterion available and used in the design are the Government breakwaters in Lake Champlain and in similar lakes. It was recognized that at times of high water and rough weather some of the spray would reach the track even if the latter were twice its present height above low water mark, and it was deemed more economical to build so as permanently to withstand any dislocation of the roadbed by the waves, and to neglect the spray action. It was thought that for a few days in the spring and fall ice might form from spray on the rails, but that it could be removed by salt. This expedient, however, has not been necessary, and there has been absolutely no trouble from spray, although occasionally a few light drops dash to the top of the telegraph poles. The embankment between Colchester Point and Allen's Point (named for Ethan and Ira Allen, who had a farm there), is curved to fit a sand reef most of the distance. A straight line between the two ends would come into deeper water and involve much heavier quantities.

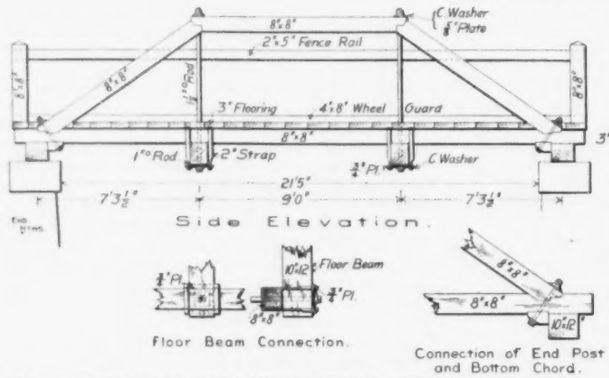


FIG. 5. DETAILS OF OVERHEAD TIMBER HIGHWAY BRIDGE, RUTLAND-CANADIAN R. R.

LAND CUTS AND FILLS.—The work on land includes nine rather heavy clay and rock cuts ranging from 16 to 35 ft. deep, and from 1,200 to 8,500 ft. length. The total earth excavation on the line was about 700,000 cu. yds., and the total rock excavation about 200,000 cu. yds. The lake embankments were measured in embankment only, and comprised nearly 1,000,000 cu. yds. of rubble thus measured. The shovels engaged in handling the material for the rubble embankments were one improved Bucyrus, weighing about 90 tons, three Marion company's Model G, and two Marion company's Model A. They were engaged about sixteen months and worked double shift about one-fourth of the time. Besides these on the lake embankment work, there were on the land grading one large shovel and three small ones, or a total of ten shovels on the entire work.

ORGANIZATION.—During the construction the work was divided into six residencies, of about eight miles each, under the following named resident engineers: G. B. Boggs, F. R. Davis, B. M. Hayward, G. R. Heckle, I. S. Lhoyd, H. Lindsay, G. L. Mattice and G. R. Olney. Immediately after the right of way was secured the telegraph line was built and used for telephone connecting all resident engineers' offices and all heavy and important parts of the work with the chief engineer's office at South Hero, which also had public long distance connection, the gaps at lake crossings being supplied with rubber-covered cable. The chief engineer's office assistants comprised a clerk, a stenographer, the draftsman, Mr. W. H. G. Mann, and two or three assistant draftsmen and computers. Every afternoon or evening each resident engineer and inspector reported to the engineer's office by telephone the events of the day, the message being taken in shorthand by the stenographer and typed. The more important reports were confirmed by letter. Special happenings were reported at any time of the day as they occurred. When the chief engineer was out on the work he received these reports and gave instructions by telephone from the various telephone booths along the line. The Consulting Engineer on location was Mr. R. W. Leonard, M. Can. Soc. C. E. On the latter part of construction there was a principal assistant engineer, Mr. A. L. Bowman, Mem. Am. Soc. C. E., during the heaviest work near the end, and later Mr. I. S. Lloyd, during the finishing up part. The designing and constructing engineer of all the steel bridges was Mr. C. F. Stowell, M. Am. Soc. C. E.

The road was built by the Champlain Construction Co., which also performed all the engineering and legal services. This company sub-let all the construction, except bridge super-structures, to O'Brien & Sheehan, of New York, General Contractors. The bridge super-structures were built by the Edge-Moor Bridge Works, of Wilmington, Del., except the short girder span which was built by the Rochester Bridge and Iron Works. The President and Treasurer of the Champlain Construction Co. are, respectively, Mr. Percival W. Clement and Mr. Henry G. Smith. Mr. Clement authorized the construction of the lake embankment between Colchester Point and Allen's Point, notwithstanding the criticism that such construction was unprecedented, and thus made the island route possible. The preliminary surveys began in November, 1898. Several lines were run on both the island and the mainland route. Bids were received and contract awarded February 8 and 9, 1899. Ground was broken March 9, 1899, and the road was opened for traffic December 16, 1900.

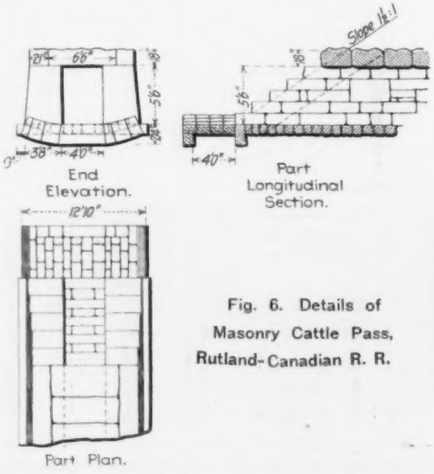


Fig. 6. Details of Masonry Cattle Pass, Rutland-Canadian R. R.

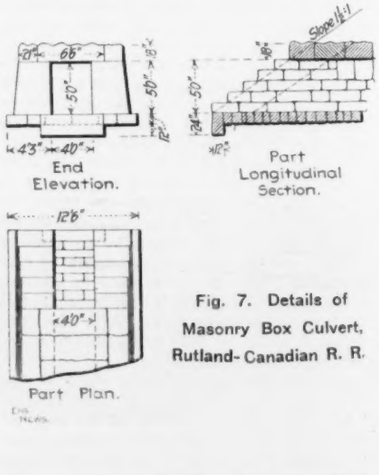


Fig. 7. Details of Masonry Box Culvert, Rutland-Canadian R. R.

AGRICULTURAL ENGINEERING.*

By Elwood Mead, M. Am. Soc. C. E.†

This branch of engineering is as yet in a nebulous state in this country. So little attention has been given to it that it has no clearly defined limitations, if indeed it exists at all. Professor Shaler, of Harvard, holds to the latter view and says that there are no trained agricultural engineers in this country, nor institutions of learning which claim to train such engineers. It is believed that this is unfortunate because there is both need and opportunity for such men. The rapid growth of the nation in population is making it desirable that large areas should be made habitable which cannot be cultivated without reclamation work requiring both a knowledge of agriculture and engineering. The swamp lands of the East need to be drained; the arid lands of the West to be watered. To do this in the best way requires a knowledge of subjects now taught in only a few of our schools of civil engineering. Mechanical engineers are working a revolution in agricultural methods by improvements in farm implements and machinery and they are destined to do more in the near future. They have not been trained for this work and with such special training they will be more efficient in the future. The object of this paper is to show the relation of engineering to the growth and prosperity of our greatest industry and to urge that schools of instruction be established which will be as fitly planned and fully equipped as the schools of law, medicine and civil engineering now are.

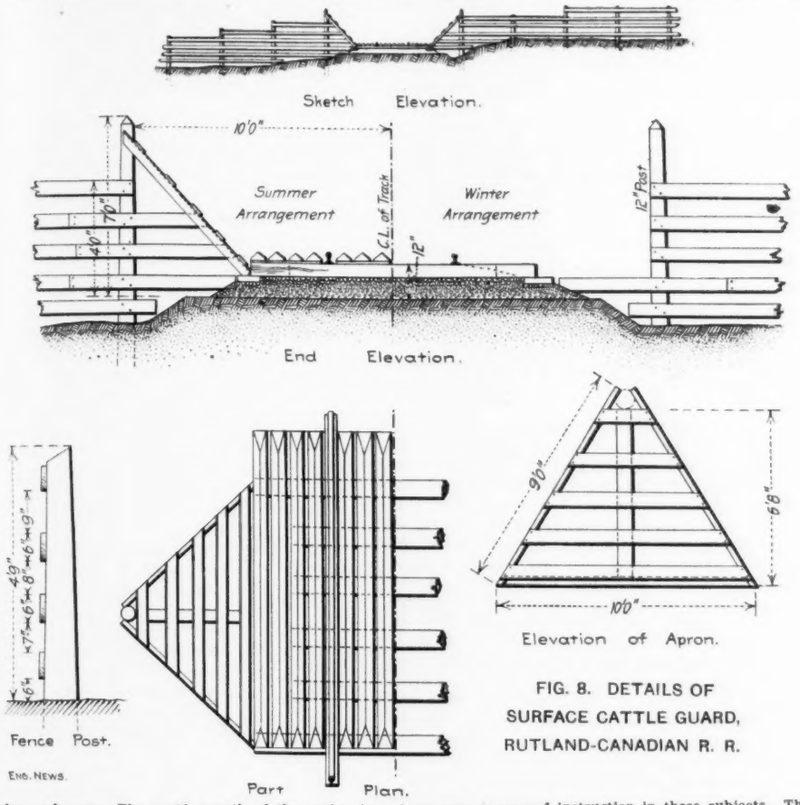


FIG. 8. DETAILS OF SURFACE CATTLE GUARD, RUTLAND-CANADIAN R. R.

ENG. NEWS.

Let us consider some of the reasons for believing that it is soon to become as important a profession or calling in this country as it is in Europe, and why there is need for better facilities for research and instruction than are now provided.

IMPORTANCE OF AGRICULTURAL IMPLEMENTS AND MACHINES.

The shorter hours of labor and lighter toil in factories have created a labor problem on the farm. The establishment of an eight or ten-hour day in the city has caused the worker in the country to refuse to labor from sunup to sundown. In order to meet these new conditions the farmer has had to plan his work with more care than in the past. He must lay out his fields and design his buildings to save in his outlay for labor and economize by the expenditure of large sums of money in the purchase of machinery of the latest and most approved types. He would not have succeeded as he has without the coöperation of the inventor and manufacturer.

In my boyhood corn was dropped by hand and covered by a hoe. Its early cultivation was all by hand labor and the cutting and shocking of corn fodder was the most laborious and disagreeable work of the year. In many Western States it has been impossible for several years to secure men to do the last-named work. All this is now being changed. Corn is planted by machinery, the hoe has disappeared in its cultivation, and recently machines for cutting and shocking corn fodder, for shucking the ears, shredding the blades and splitting the stalks for the paper maker have come into use. In less than a quarter of a century every detail of the production of our leading cereal has been revolutionized by inventions.

The part which machinery plays in farming operations is shown by the fact that more than $150,000,000 is invested in factories for its manufacture, while the annual output is worth more than $100,000,000. The purchase and repairs of machinery is one of the principal expenses of the modern farm. This is particularly true in many parts of the West, where farming is carried on on an extensive scale with all of the system and business organization which characterizes any modern industry. On a single farm in Dakota there are in operation 67 plows (11 of them being gang plows), 64 harrows, 32 grain drills, 34 harvesters, 7 traction engines and 50 wagons. On one of the bonanza farms in California there are 100 wagons and over $100,000 is invested in farm machinery.

The changes in implements used on the farm are not more radical than the manner in which the different forces of nature are being utilized. Steam, gas, electricity are all being largely made use of to replace animal power. The traction engine and automobile dispute the country roads with the horse Electricity is beginning to turn wheels on the farm as well as in the factory. The cheapness with which electricity can be transmitted long distances is making available the unused water power of the mountain regions of the West for new and hitherto unthought of purposes. Water is being pumped for irrigation by power transmitted from mountain canyons 240 miles away, and it seems only a step from this to the plowing of fields and the threshing of grain by the same agencies.

With the best tools this country will continue to outstrip its competitors in the race for the world's markets. The significance of this is appreciated by European countries, where institutions for the study and betterment of farm machinery and for the education of farmers in its more effective use are supported by the State with highly beneficial results. Thus far practically nothing has been done in this country in the way of original research, and in only a few of the agricultural colleges is there any systematic training in the principles of design or in the construction or operation of different types of farm machinery.

DRAINAGE AND IRRIGATION.

Let us now consider the relation of drainage and irrigation engineering to the agricultural development of this country. Both of these branches of agricultural engineering have been of great practical importance in European countries for many years, but it is only recently that we have awakened to a realization of the part they are to play in increasing the boundaries of cultivation and the opportunities for home-making in the United States. The first century of our national life was devoted to subduing the continent. We were active but in a destructive fashion. In many places the soil was skinned rather than cultivated, so that in the beginning of our national life we are confronted by large areas where the fields are impoverished and abandoned, washed with gullies and overrun with briers and weeds. We have slashed away our forests, ruined water powers and wrought injurious changes in our climate. The indications are, however, that we have learned wisdom and that our development in the future will be along different lines. There is no longer an unsettled area to take the place of land rendered unproductive by erosion or exhausted by wasteful methods

FIG. 9. VIEW OF LAKE EMBANKMENT, RUTLAND-CANADIAN R. R.

As we are considering something which is needed rather than something which exists, it seems well to define what agricultural engineering, as dealt with in this discussion, includes. It will be held to embrace the laying out of farms, designing of farm houses and farm buildings, problems of sewage, sanitation and water supply of farms, irrigation and drainage of lands, and the designing and operation of farm machinery, including therein the various applications of power to farm work. Roads and road making, which are of vital importance to the farming classes, are not included because so closely related to the other work of the civil engineer, and already a prominent feature in courses of instruction in schools of civil engineering.

The civil engineers engaged in drainage and irrigation were not trained for this work, although a few colleges have now courses of instruction in these subjects. Those who have qualified themselves in the school of experience have undergone many unpleasant experiences, and their employers have sometimes been called upon to pay some large tuition fees. The larger problems of the future in both these fields render it desirable that the engineers who are to solve them be specially trained for their tasks.

Anyone who will seriously consider the part which machinery plays in the farming operations of this country cannot fail to be impressed with the enormous gain to farmers by an improvement either in the design or operation of harvesters which would increase their average day's work a quarter of an acre, or the saving which would come by lengthening their period of use a single season. Within the past ten years a new kind of plow has been put on the market. The departure from former types is revolutionary. Is it an improvement or a fad? If one, the gain is stupendous; if the other, the waste of the experiment is serious.

With this brief outline of what agricultural engineering includes, let us consider some of the reasons for believing

*Abstract of a paper read before the American Association for the Advancement of Science, in Section D, Mechanical Science and Engineering, Washington, D. C., Dec. 31, 1902.

†Chief Engineer Irrigation Investigations, U. S. Department of Agriculture.

of tillage. The unoccupied areas, both East and West, must nearly all be dealt with by the engineer before they can be cultivated. Nearly $200,000,000 has already been expended in the construction of irrigation works, but the construction of storage reservoirs to hold back the floods and of immense main line canals to divert our largest rivers is largely a work for the future. These will afford employment and opportunities for a large number of properly trained young men.

Drainage is only second to irrigation in its possibilities for extending the area now cultivated. Some of the most productive lands of California have been reclaimed by dykes and drains. The marsh lands along the Atlantic and Gulf seaboards are estimated by Prof. N. S. Shaler to have a productive capacity four times that of the State of Illinois. All that they need is drainage. The newspapers report that $4,000,000 is soon to be expended in reclamation work of this character between the city of New York and Portland, Me. A drainage canal 60 miles long, 60 ft. wide and 7 ft. deep is now being excavated in Indiana. Many of the States of the Mississippi Valley have passed State drainage laws and provided for carrying out this work as a public improvement. In time all of the larger irrigated districts of the West will have to be drained. Comprehensive plans will be essential to success.

IMPROVEMENTS IN FARM BUILDINGS AND IN THE ENVIRONMENT OF THE FARM.

It will be admitted without question that the designing of the different buildings required on the modern farm is a far more complex matter than it was 50 years ago. At the earlier date these buildings were mainly storage places for implements and crops and shelters for stock, but in recent years these buildings have become as complex in construction and need to be as carefully planned as factories. Silos to secure larger returns in the feeding of certain crops, the grinding of grain and cutting of fodder are illustrations of these changes in methods. Not only has this resulted in a broadened opportunity for study in the improvement of designs of these buildings, but the question of material to be used in their construction must receive attention in the near future. So long as timber was abundant and cheap lumber was the principal material used, but with the removal of our forests and the increasing cost of wood the time is not far distant when brick, concrete, stone and metal will have to be more largely used. Moreover, under modern conditions where high-bred, high-priced stock is grown, the questions of stable sanitation, lighting and ventilation have assumed an importance second only to that of house ventilation, but the data upon which to base an efficient system of ventilation alone are of the most limited, unreliable character.

It is in every way desirable that farm life should be made more attractive and that more attention shall be given hereafter to beautifying the environments of rural homes through the artistic laying out of gardens, buildings and roads. For the performance of this work in the best manner, the services of agricultural engineers are required and we already find here and there men who have had opened to them careers of usefulness and influence through having given special attention to these subjects. Without doubt this phase of agricultural engineering is destined to have as important a place in this country as it already occupies in European countries, and it is time that provision should be made for systematic instruction along these lines.

RELATION OF THE U. S. DEPARTMENT OF AGRICULTURE AND THE AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS TO THIS SUBJECT.

The agricultural colleges of this country have in recent years given serious attention to this subject. A committee on methods of teaching agriculture has formulated a course which has been published in Bulletin 45, pp. 6 and 7, of the Office of Experiment Stations. The University of California and the State Agricultural College of Colorado offer courses in irrigation engineering, and Illinois and Wisconsin in farm machinery. The interest shown in this subject seems to show that the time is ripe for further action. All agricultural colleges should give instruction in those elementary engineering principles which have a practical bearing on farm management, while a few of the better equipped institutions should provide thorough courses, having as a foundation a general course in mechanical and civil engineering. Men so trained would, I believe, be in immediate demand in the management of industrial and engineering enterprises connected with agriculture.

One difficulty which now confronts our colleges is the lack of text books and of properly classified and verified information. There are many subjects about which we know little, and where the need of advanced research is now urgent. It is believed that the U. S. Department of Agriculture can by coöperating with the agricultural colleges and experiment stations do much by collating and publishing the results of investigations in this and other countries and by aiding the different institutions in making researches along the line of their special equipment. Dr. True, Director of the Office of Experiment Stations, has long felt a deep interest in this matter, and it was largely through his efforts that a committee to plan a course of study was formed. This was supplemented at the last annual meeting of the association of agricultural colleges and experiment stations by a committee on agricultural engineering. The irrigation investigations of this office, which has for several years been studying the problems of irrigation, has recently broadened its work by including drainage and the applications of power to pumping and other kinds of farm work. The demand for the reports of these investigations by the professors and students of Western colleges leaves no doubt of the benefits of a further broadening of these researches to include the whole field of agricultural engineering.

RULES FOR WORKING LOADS OF WIRE ELEVATOR ROPES.

By H. C. Newcomer, Captain, Corps of Engineers, U. S. A.*

After the admirable article on "Determining the Size of Hoisting Plants" which appeared in Engineering News of Oct. 16, 1902, any further remarks on the subject may seem superfluous, but an investigation into the present common practice concerning sizes of wire ropes and sheaves for passenger elevators has disclosed an amazing disregard of the usual factors of safety considered advisable in the design of engineering structures. It is believed, therefore, that a statement of the information gained may be of interest to a considerable number of persons and may possibly elicit further discussion that may lead to material improvement in methods of designing such plants.

A recent application for permit to install an elevator plant in a hotel in Washington, D. C., was disapproved on the ground that the sizes of wire ropes and sheaves did not comply with the building regulations on that subject. It was proposed to use ⅝-in. iron wire ropes on sheaves of varying diameters, the least of which was 30 ins., the static load on each rope being 750 lbs. The regulations give a minimum diameter of 42 ins. for this size of rope. The building inspector suggested the use of ½-in. ropes instead of the ⅝-in. as they had sufficient strength and would comply with regulations as to size of sheave. The designer of the plant made a vigorous protest against the adverse decision, claiming that the plans were well within the limits of good practice. He seemed to be particularly struck with the apparent absurdity of allowing smaller ropes where larger ones were rejected for the same service.

In the absence of Captain Harding, to whom such questions are ordinarily referred as being in charge of the Building Department, I was asked to look up the matter to ascertain whether the regulations were well founded, so as to justify the District authorities in requiring compliance with them. The portions of the regulations pertinent to this discussion require that a passenger elevator "shall have at least two hoisting ropes attached thereto, and two ropes attached to any counterweight used in connection with the elevator. All ropes will be independently fastened at their terminals." Also "the following are adopted as the standard sheave for ropes of given diameter with 19 wires to the strand:"

Trade No.	Diameter, ins.	Weight per ft. in lbs. with hemp center.	Breaking load in tons of 2,000 lbs.	Proper working load in tons of 2,000 lbs.	Minimum size of diam. of drum, or sheave, ft.
1	2¼	8.00	74.0	15	13
2	2	6.30	65.0	13	12
3	1¾	5.25	54.0	11	10
4	1⅝	4.10	44.0	9	8½
5	1½	3.65	39.0	8	7½
5½	1⅜	3.00	33.0	6½	7
6	1¼	2.50	27.0	5½	6½
7	1⅛	2.00	20.0	4	6
8	1	1.58	16.0	3	5¾
9	⅞	1.20	11.50	2½	4½
10	¾	0.88	8.64	1¾	4
10¼	⅝	0.60	5.13	1¼	3½
10½	9/16	0.48	4.27	¾	2¾
10¾	½	0.39	3.48	½	2¼
10a	7/16	0.29	3.00	⅜	2
10⅞	⅜	0.26	2.50	¼	1½

It was at once seen that the above table is practically identical with those given in manufacturers' handbooks for general hoisting purposes for Swedish iron rope consisting of six strands of 19 wires each. It allows a working load of about one-fifth of the breaking strength of the rope, and is apt to give the impression to the unwary that it provides a factor of safety of five.

*Assistant to the Engineer Commissioner of the District of Columbia, Washington, D. C.

I quote the following paragraphs from the [illegible] of one of the leading manufacturers:

The *working loads* were calculated at *one-fifth* the *breaking strains*, but it should be understood that [illegible] factor of safety is not recommended for all cases, as it [illegible] imperative to determine for every set of conditions a [illegible] sonable factor of safety. For instance, elevator [illegible] seldom have a load of more than one-tenth or one-fifth [illegible] of their breaking strain.

The *minimum sizes of drums or sheaves* given in [illegible] tables were calculated on a basis of a working load [illegible] one-fifth the breaking strain, and provided that [illegible] shall not have their wires strained beyond the elastic [illegible] when passing around the drums or sheaves indicated. While the theoretical sizes for cast-steel ropes are smaller than for the corresponding iron ropes, because the elastic limit of the former is much higher than of the latter, and the modulus of elasticity is nearly the same for both, it is better to use the larger sizes of drums and sheaves for steel ropes, because when steel wire becomes worn or nicked it cracks very easily.

The inference seemed to be obvious that in the opinion of the manufacturers the table in the regulations might be properly used for ordinary hoisting plants, but was not considered to be applicable to passenger elevator plants which naturally demanded larger factors of safety. So far we not only appeared to be justified in refusing to lower the requirements of the regulations, but were rather bound to increase them in the interests of public safety.

It was seen that a rational solution of the question necessarily involved a determination more or less approximate of the stresses developed in the wires due to bending of the ropes around the sheaves. The following theory of the bending stresses has been adopted as fairly satisfactory: Let E represent the coefficient or modulus of elasticity;

" I " the moment of inertia of cross-section of the bent wire;
" R " the radius of curvature of neutral axis of bent wire;
" M " the bending moment;
" P " the stress in pounds per square inch in extreme fibers of bent wire;
" d' " diameter of wire;
" d " diameter of wire rope;
" D " diameter of drum or sheave;
" L " the allowable working load in pounds to be supported by rope;
" S " the ultimate strength of the rope in pounds;
" a " the area in square inches of cross-section of metal in rope;
" K " the factor of safety;

Then combining the fundamental equation deduced in the theory of transverse stresses, viz.:

$$\frac{E\,I}{R} = M \qquad (1)$$

with the equation giving stress in extreme fibers due to bending, viz.:

$$P = \frac{M - \frac{d'}{2}}{I} \qquad (2)$$

we obtain for stress due to bending:

$$P = \frac{Ed'}{2R} \qquad (3)$$

It appears to me to be justifiable to assume the radius of curvature (R) to be equal to the radius of the drum or sheave, in which case the preceding equation becomes:

$$P = \frac{Ed'}{D} \qquad (4)$$

It is doubtless true that the actual radius of curvature is somewhat greater than that of the drum (and therefore apparently the stress by formula too great), as is assumed in the formula adopted by the Trenton Iron Co., in which an allowance is made for the average distance of the wire from the surface of the drum, and also an allowance for excess in length of wire, due to compound spiral form, over length of corresponding portion of rope. On the other hand it should be noted that the formula is based on the assumption that each wire is bent independently of the others, whereas as a matter of fact these individual bending stresses in certain wires may be materially increased by stresses transmitted

to these wires through frictional forces developed between wires. This becomes very apparent when through lack of proper lubrication the rope gets rusty and the outer wires break around sheaves where they gave satisfactory service when in good condition. The theoretical expression for bending stress adopted by the Trenton Iron Co. gives as bending stress for a ⅝-in. rope on a 30-in. drum a value about 7% less than that resulting from formula (4). It appears reasonable to me to suppose that the stresses due to bending are increased by at least this percentage due to internal friction in the rope, even when properly lubricated, and as the formula has great advantage on account of simplicity, it has been adopted. To make it more convenient of application in the ordinary case of rope consisting of six strands of 19 wires each, in which case the diameter of the wire is 1-15 of the diameter of the rope, the stress is given in terms of d as follows:

$$P = \frac{Ed}{15\,D} \qquad (5)$$

Assuming a value of 27,000,000 lbs. for E, in case of iron wire rope, we obtain:

$$P = 1{,}800{,}000\,\frac{d}{D} \qquad (6)$$

It at once becomes apparent how important the bending stresses are. One of the common rules used is to make the diameter of the drum 50 times the diameter of the rope, in which case it is seen that the bending stresses alone are 36,000 lbs. per square inch in extreme fibers.

Reverting to the original expression for P, in order to obtain a formula of general application for allowable loads, we can at once write:

$$\frac{S}{Ka} = \frac{L}{a} + \frac{Ed'}{D} \qquad (7)$$

$$\therefore\ L = \frac{S}{K} - \frac{E\,a\,d'}{D} \qquad (8)$$

Adapting this to the ordinary case of rope having six strands of 19 wires each, for which a may be taken equal to $^2/_5\ d^2$, and $d' = {}^1/_{16}\ d$, we obtain:

$$L = \frac{S}{K} - \frac{2\,E\,d^2}{75\,D} \qquad (9)$$

Assuming for iron wire E = 27,000,000, and for cast-steel wire E = 28,500,000, we obtain for iron wire:

$$L = \frac{S}{K} - 720{,}000\,\frac{d^2}{D} \qquad (10)$$

and for cast-steel wire

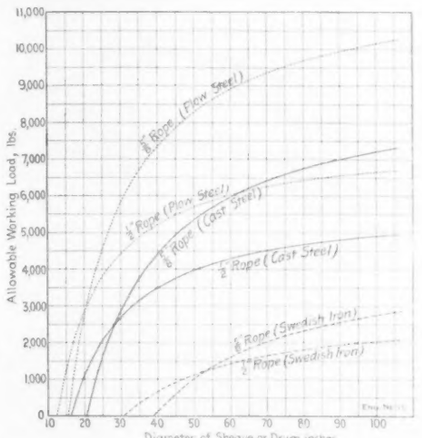
$$L = \frac{S}{K} - 760{,}000\,\frac{d^2}{D} \qquad (11)$$

It only remains to select a factor of safety in order to obtain a working formula. Judging from practice in other uses of iron and steel, and impressed with the relatively arduous conditions attending this use in hoisting ropes, I at first thought a factor of safety of four would be the least that could be justified for conservative practice such as should characterize municipal regulations. Further consideration, however, making allowance for the arguments of those who are closely identified with elevator construction and who strenuously object to such revolutionary treatment of the subject, has convinced me that it would be allowable to reduce the factor of safety to three. This value is used in the tables of the Trenton Iron Co., which were published in very convenient form in Engineering News of Oct. 16, 1902, and with this value the formula gives results that practically accord with these tables. The accompanying diagram has been prepared by use of the formula to illustrate the influence on allowable load of the size of sheave and strength of material used in rope.

Even with this low factor of safety it will be seen that the iron ropes would be practically excluded from elevator service, where on account of the limited space the sheaves usually range from only about 24 or 30 ins. to 42 or 44 ins. in diameter.

It appears that over 90% of the elevator ropes now in use are of iron wire, and judging from replies received from elevator builders and insurance companies the common rule of proportioning ropes and sheaves is to assume one-tenth the breaking strength of rope as its proper load and make the sheave 50 times the size of the rope. Substituting these values in the formula for iron rope it will be seen that there would result a factor of safety slightly less than two.

In the light of this fact it may be of interest


Allowable Working Load, lbs.
Diameter of Sheave or Drum, inches.
⅝ Rope (Plow Steel)
¾ Rope (Plow Steel)
⅝ Rope (Cast Steel)
¾ Rope (Cast Steel)
⅝ Rope (Swedish Iron)
¾ Rope (Swedish Iron)

Working-Load Diagram for Wire Ropes on Drums Varying in Size.

(Calculated on the basis that the extreme fiber stress, including bending stress, shall equal one-third the ultimate strength of the wire.)

to quote from one of the elevator companies, as follows:

> Our practice is to make the diameter of the sheave 50 times the diameter of the rope, and we use the Roebling list of cables with their given breaking strains, allowing a *factor of safety of ten to one* for passenger service and eight to one for freight service.

The italics are mine. Another elevator company uses practically the same language.

Such a loose use of the term "factor of safety" could hardly come from such a source through ignorance of the actual conditions, but there can be little doubt that it is misleading to the ordinary person.

A prominent manufacturing company sent a special representative to discuss the matter with us and give us the benefit of its large experience, as it was recognized that aside from the local importance of the matter a regulation on the subject adopted in Washington might influence the municipal authorities in other cities. This representative advised that the elastic limit of the material be adopted as the maximum stress to be allowed in applying the proposed type of formula. The elastic limit of the iron wire may be taken at 60% of the ultimate strength. In the higher grades of steel wire it runs up to between 80 and 90% of ultimate strength. Provision could be made in the formula for increase in the pull on the rope due to very sudden acceleration or stopping of the elevator. This increase was stated, as the result of experiments, not to exceed 30% of the static load. It was pointed out that the rope retains 60% of its original strength when every outer wire is broken at any given section; that the nature of the service is such as to permit ready inspection and replacement of damaged ropes; that the question at issue was therefore not so much one of safety as of the life of the rope. It was further asserted that iron ropes give much more satisfactory service than steel ropes, and that the assumption of any materially smaller maximum stress than the elastic limit would bar out existing plants giving satisfactory service.

Such arguments from one in a position to speak with authority naturally made us hesitate as to proper course to pursue, but they have not convinced me that it would be proper to use a formula that at best could only be applicable to new rope in first-class condition. The necessary wear on ropes incident to the service, the inevitable variations in strength of new ropes, the almost certain lack of proper care in numerous cases, all seem to indicate that no unreasonable burden would be imposed by requiring at least a factor of safety of three. This may be illustrated by a recent case in Washington. Notice was served on a hotel owner to renew the ropes on a certain elevator. He promptly protested against the order, stating that the elevator had just a brief time before been approved by the inspector of an insurance company whose inspections were entitled to much more confidence than those of the Building Department. Moreover he stated, evidently thinking this would clinch the matter, that the elevator had had practically almost no use during the season since the Building Department had inspected and approved it last spring. The explanation proved to be that the cage had been in one position during the summer, and the portion of the rope across the top of the shaft had rusted. The owner promptly capitulated when he was shown the broken wires in this portion of the rope.

The question appears to narrow itself down to the point whether cast-steel ropes would give satisfactory service. If so, it is apparent from the diagram that there would be no difficulty whatever in securing with them a factor of safety of three, which appears to be impracticable with iron ropes. The principal objection to the steel seems to be that its greater hardness wears the sheaves more rapidly, with probably a resultant differential movement between ropes on same sheave that would destroy both ropes and sheave. This increased wear would be especially notable, if smaller steel ropes were used, increasing the pressure per square inch on sheave. It is also stated that when new ropes replace old ones that have worn into the sheaves the life of the ropes is much shortened, and this is said to be particularly noticable in the case of steel ropes. Nevertheless, steel ropes are used more or less and prominent elevator construction and insurance companies testify to the fact that the steel ropes give satisfactory service when of good quality. This refers to the cast or crucible steel. A striking instance of the value of high ultimate strength recently came to my notice on a grading contract where I was somewhat startled to find ⅝-in. rope on an 18-in. drum handling trains of dump cars, and apparently giving satisfactory service. On inquiry I learned it was a very high grade of steel rope with ultimate breaking strength of 20 tons, which, according to formula, would give on an 18-in. drum permissible load of about 3,000 lbs. with factor of safety of three.

The following table gives the formulas in convenient form for application for stated sizes of iron and cast-steel ropes having six strands of 19 wires each:

Size of rope.	Swedish Iron.	Cast steel.
½-in.	$L = 2{,}933 - \frac{90{,}000}{D}$	$L = 5{,}867 - \frac{95{,}000}{D}$
$^9/_{16}$-in.	$L = 3{,}667 - \frac{128{,}144}{D}$	$L = 7{,}333 - \frac{135{,}268}{D}$
⅝-in.	$L = 4{,}533 - \frac{175{,}783}{D}$	$L = 9{,}067 - \frac{185{,}548}{D}$
¾-in.	$L = 6{,}467 - \frac{308{,}772}{D}$	$L = 12{,}933 - \frac{320{,}648}{D}$

THE FOREIGN COMMERCE OF THE UNITED States, for the eleven months ending with November, shows totals of $1,212,710,063 exports, and $874,966,557 imports, says the U. S. Bureau of Statistics. These figures for the same period in 1901 were respectively, $1,328,186,131 and $800,426,231. The reduction of $116,000,000 in exports for 1902 occurs largely in agricultural products; and the fact that the loss in these products amounts to $130,000,000, shows that there is really an increase in the export of manufactures. The most striking increase in imports is in manufactures of iron and steel, amounting to $36,766,961 in value for the eleven months, as compared with $18,267,677 in the corresponding period of 1901. The reduction in agricultural exports is due largely to an increased home demand and to the loss of part of the corn crop of last year; the export of corn in eleven months having fallen from $49,561,374 in 1901, to $6,745,151 in 1902. A large home demand, beyond the capacity of our own industries, will also account for the import of manufactures in iron and steel; while nearly every article required for use in manufactures here also shows a marked increase in the import list.

PROPOSED RETAINING BARRIERS FOR THE DEBRIS FROM HYDRAULIC MINING IN THE YUBA RIVER, CAL.

Many of our readers are aware that the tailings from the large hydraulic mines in California have caused great damage by overspreading agricultural lands, and accentuating the damage due to floods. In 1880, it was estimated that in the bed of the Yuba River alone there were more than 140,000,000 cu. yds. of accumulated tailings. In consequence of the damage caused by the hydraulic mining industry, suits followed to enjoin the mines. An effort was made under State direction to store the debris by means of dams in 1880-1881, but such work was discontinued, after the outlay of several hundred thousand dollars, partly owing to the ill-success of the dams, but principally owing to the divided sentiment between the agricultural and mining sections of the State. Litigation continued for years while efforts were being made by the State to secure the aid of the Federal Government through its interest in keeping the rivers open for navigation. The effect of such litigation was to practically stop hydraulic mining from 1884 to 1893.

Finally, by an act of Congress, known as "the Caminetti act," approved Mar. 1, 1893, the California Débris Commission was created with jurisdiction over hydraulic mining operations in the valleys drained by the Sacramento and San Joaquin River systems. The Commission required hydraulic miners to make an application for a license to mine, and of the 1,565 applications made since its organization the Commission has granted 455 and has revoked 172 permits. The Commission at first confined its work to directing the manner in which débris impounding should be carried on by the miners; and as the methods used have proved effective, as far as they go, a very brief description is not out of place.

Two types of barriers are in use, brushwork and log cribbing. Brushwork is used in small ravines not subject to great freshets, and 20 ft. is the usual limit of height of such barriers, although the barrier when first built is generally but 5 or 6 ft. high, layers of brush being subsequently added as the reservoir filled up with débris. The brush is cut in lengths of 8 to 10 ft. and laid in layers butt end down stream, the layers being separated by small logs, 5 to 12 ins. diameter, laid across the brush and lengthwise of the dam. The logs or poles serve mainly as spreaders to make up the difference in thickness between the butts and top ends of the brush. Wire is sometimes used for binding, and the whole weighted with gravel, or enough finer brush is used to make the structure comparatively watertight, so that a settling basin of water is always maintained above the barrier when the mine is in operation. The top of the barrier down stream is kept about 2 ft. higher than it is up stream to insure that the tops of the brush will become imbedded in débris. The fact that no considerable height of brush can be laid at one time on account of the springiness and lack of compactness, of course, limits the use of such structures.

The log crib structures are made so as to form "log cabin" wells about 15 ft. on a side, the logs being notched and drift-bolted in the ordinary way. The cross-logs are inclined so that the down stream end is 2 or 3 ft. higher than the up stream end. At first only the lower 5 or 6 ft. of the wells were filled with stone, and the débris allowed to complete the filling above; but this has not proved satisfactory, so the full depth is now required to be rock-filled. Thus, even after the logs decay there is a more or less effective rock-filled dam left.

The limiting height of the log dam is usually 40 ft., but plans have been approved for dams of even double that height, although so high a dam was never actually built.

Instead of building a dam to the height of the proposed depth of deposit of tailings, and completing the dam as rapidly as possible, the plan is to first build a shallow barrier of brush faced with dry rubble, protected at the toe with sheet piling. When sedimentation shall have reached a level within about 3 ft. of the crest of this barrier, additions to its height are to be made, thus entirely avoiding the necessity of building a dam of weight and strength sufficient to withstand the pressure of water of great depth. There are to

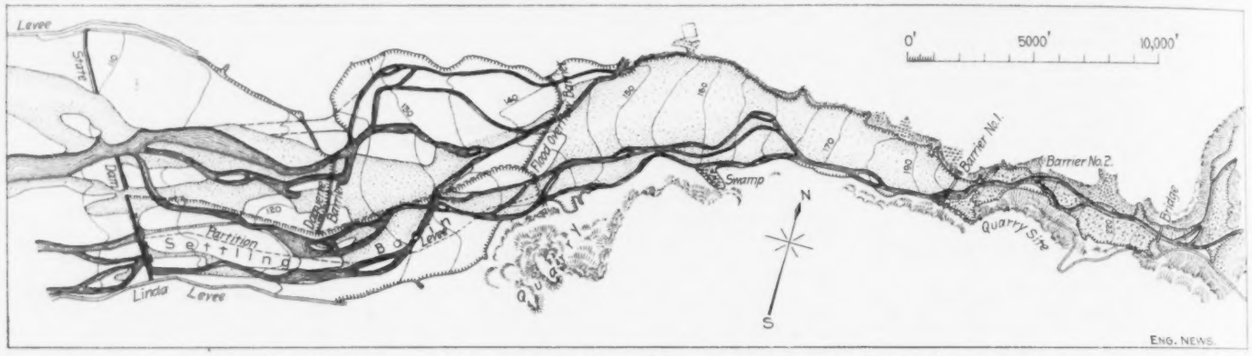


FIG. 1. MAP SHOWING LOCATION OF DEBRIS IMPOUNDING BARRIERS OF THE YUBA RIVER, CAL.

In the river and harbor act of June 3, 1896, an appropriation of $250,000 was made, to be expended by the Commission under the direction of the Secretary of War. The sundry civil act of July 1, 1898, modified the act of 1896, and authorized the Secretary of War to specify that contractors for the work shall look to the State of California for pay for one-half the cost of impounding works. The act of March 3, 1899, provides that the Secretary of War may, at his discretion, do the necessary work by hired labor and purchases in the open market, when the aggregate of State and Federal appropriations are available and sufficient to complete the work projected. In 1893, California appropriated $250,000, and in the year 1901 further joint appropriations of $300,000 brought the total up to $800,000, which is the estimated cost of work now projected.

The early surveys of the Commission made by Mr. Hubert Vischer, Asst. Engr., led to the consideration of a project, since abandoned, but referred to as "the project of 1898," in which it was proposed to build a high dam at what is known as the Narrows of the Yuba River.* Since the impounding capacity of such a dam would have been comparatively small (35,000,000 cu. yds.) the projector contemplated the building of a diverting channel or canal to carry the finer débris to a settling basin 28 miles distant; but as this involved considerable tunneling, and a total expenditure of more than a million dollars, the project was abandoned upon Mr. Vischer's recommendation.

Later surveys and study of the problem finally led Mr. Vischer to devise a method of impounding the detritus at considerably less expense, and in a manner wholly novel; and, as will be seen later, this novel method is applicable to other and even more important hydraulic works, such as ordinary dams for impounding the waters of muddy streams for power purposes. In brief, Mr. Vischer's new project, which has been adopted by the Commission, is as follows:

*The Yuba River was found to be the source of more débris accumulations than all other tributaries of the Sacramento and San Joaquin put together. It is interesting to note that the material mined in 1901 by the hydraulic process under permits issued by the Commission is estimated at about 1,308,000 cu. yds.

be four such barriers in the Yuba River. Barrier No. 1 will be located about ¾-mile below Barrier No. 2, serving also to secure a water cushion for Barrier No. 2, and preventing erosion of the gravel at the toe thereof. Barrier No. 2 is to have a height of about 40 ft. above the present bed and a crest length of 1,000 ft., and is to be built up gradually; while Barrier No. 1 will have about the same crest length and a height of 18 to 26 ft. Both barriers are expected to raise the plane of river deposits about 40 ft., and hold about 36,000,000 cu. yds. of coarse tailings on an assumed grade of 15 ft. per mile, at a cost of about 7-10-ct. per cu. yd. for such impounding.

The next, or Flood Overflow Barrier, is to be located about three miles down the river. It is to be a low structure, 4,000 ft. in length, consisting of some cribwork, with rockfilling, sheet piling and paving. During floods (assumed at 125,000 cu. ft. per sec.) it will be submerged; at ordinary river stages it will divert all the water into a settling basin.

The last, or Daguerre Barrier, 1½ miles further down stream, will have a crest length of 3,000 ft. and a general height of 14 ft.; it will be a brush and gravel structure heavily faced with rock. The tailings are too deep to admit of going down to rock foundations.

Barrier No. 1 and Daguerre Barrier serve principally to divert a large portion of the flow of the river through excavations in the solid banks, thus making it easier to take up the shock and prevent erosion at the points of greatest drop.

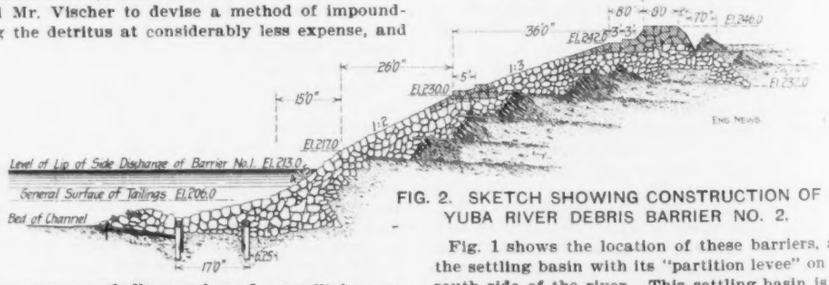


FIG. 2. SKETCH SHOWING CONSTRUCTION OF YUBA RIVER DEBRIS BARRIER NO. 2.

Fig. 1 shows the location of these barriers, and the settling basin with its "partition levee" on the south side of the river. This settling basin is intended to impound the fine silt, and has a capacity of 14,000,000 cu. yds. that by extension of the levees further down stream may be increased to 64,000,000 cu. yds. Inlet and outlet weirs are to be provided in the levee walls of the settling basin.

Fig. 2 shows Barrier No. 2 in sufficient detail to render further description unnecessary. In closing it may be well to emphasize the novelty of the plan of progressively increasing the height of the barriers from year to year, keeping pace with

the sedimentation, for there are not a few projects of damming streams for power purposes that have been abandoned because of the certainty that silt would soon greatly reduce the water storage capacity of the reservoirs. If cheap silt impounding barriers can thus be built farther up stream, the problem of power development can be solved.

The first contract, for a part of Barrier No. 1 (involving the expenditure of about $28,000), has been let to the Atlantic, Gulf & Pacific Company, of New York, and preliminary work under the contract commenced on Nov. 13, 1902. It is expected that other parts of the project will be started as early in 1893 as the river will permit.

The members of the California Débris Commission during the two past years were: Col. S. M. Mansfield, to Feb. 9, 1901; Col. Jared A. Smith, from Feb. 9 to Sept. 22, 1901; and Lieut.-Col. D. P. Heap, since Sept. 22; Lieut.-Col. W. H. Heuer; Capt. Herbert Deakyne, to Aug. 23, 1901; and 1st Lieut. R. P. Johnston, since Aug. 23.

COKING IN BEE-HIVE OVENS WITH REFERENCE TO YIELD.*

By Charles Catlett,† M. Am. Inst. M. E.

My attention having been called several years ago to the possibility of increasing the yield of coke per ton of coal, as obtained in certain bee-hive ovens, I called the attention of the Institute to the matter at the New York meeting in 1899. I have had occasion since to witness the indifference with which this matter is ordinarily considered, and, on the other hand, the marked improvement which comes from even a most perfunctory effort in that direction; and I am almost tempted to say that nothing in connection with the coking of coal is at present so important. There are other factors, which are fundamental and necessary; but they have been considered already; while the question of yield is, as a rule, absolutely ignored, or some figure is taken as the result of a special burning of one or two ovens, and the assumption is made that the whole battery is yielding at that rate. The uncertainty of this assumption I may illustrate by saying that, in my own observation, the burning of a single oven in a battery frequently gives, by actual weight, as much as 69 or 70% of merchantable coke, while the battery as a whole was yielding only an average of 63%.

Only from careful records,checked at least once a month, of the weight of the coal going to the ovens and the weight of coke produced, can any correct idea of the actual yield be gained, or methods be modified so as to produce good results; yet, as a rule, the crudest estimates are usually the only available data. In many cases there are reasons for this loose practice. The coal is mined by measurement; the payment for drawing the ovens is in proportion to the amount of coal which goes to them; and, not uncommonly, the royalty is so much a ton of coke, not of coal. The mine-manager is tempted to increase the volume of coal mined which is paid for as a ton, and to do the same thing in charging the ovens. Nor does he wish the royalty-charge to be changed in any way. The result is that often his records do not truly show within quite a large percentage the actual weight of coal mined and charged in his ovens. Yet until he has accurate information on this point, he cannot tell what is the amount of loss under present methods, or how to improve on them. I venture the assertion that the owners of many plants in the Connellsville region, otherwise well managed, who complacently accept Mr. Fulton's statement that the yield of the Connellsville coal in coke is 66%, would be astonished should they ascertain what is their actual yield.

The effect of a slight increase in the yield per cent. is greater than is usually realized. For instance, if a battery of ovens is yielding 60%, and the yield is increased to 61%, there has been an absolute saving of one-sixtieth, or 1.66% of the total value of the coke formerly produced, less the cost of loading—since all the other expenses remain the same. I have never yet examined a battery of ovens, where the attention of the management had not been called to the yield, in which it was not possible to make an increase of from 3 to 5%. If, for purposes of illustration, we assume that the former yield was 60% (which figure does not vary greatly from the general practice), the saving of 3% would mean a total saving of 1-20 of the output, and a saving of 5% would mean a total saving of 1-12th of the output. Enormous as this difference may seem, it is exceedingly common, and at times is greatly exceeded. I know of a coking-district which, as a whole, is only yielding 55 or 56%, though the coal could readily be made to yield from 65 to 70%.

The loss of the byproducts in the 63,000 bee-hive coke-ovens in this country is an appalling waste of natural supplies, and has been a fruitful source of discussion as to the wastefulness of our methods. If, however, I am right in my belief that my own experience fairly represents the conditions at the majority of the ovens in operation, there are at least 1,000,000 to 2,000,000 tons of coke annually consumed and lost in our bee-hive ovens which, by anything like reasonable care and attention, could be saved. As the average value of coke in 1901 was more than $2 per ton, this represents a very large money value.

This waste is worse than useless. The excess of heat available from the gases, as shown by tests of a great variety of coals in the retort-ovens and ordinary tests of single bee-hive ovens, demonstrates to my mind that there is not a good coking coal which could not be coked in bee-hive ovens by the heat derived from the combustion of its gases alone, and that the burning up of any coke which has already been formed is therefore a positive, unnecessary loss.

But more than that: the burning of a portion of the coke necessarily results in the deposition of ash on the remainder. This retards the transmission of heat from the hottest portion of the oven (just above the coke) to the unburnt portion of the coke toward the bottom of the oven; and, moreover, when the oven is watered down, this ash is washed through the pores of the coke and retained there, thus increasing the ash beyond its normal and proper proportion. A careful examination will disclose this ash in the pores of the coke. I have known cases, where the coal was naturally high in ash (and therefore the ash content was a matter of the greatest importance), in which enough coke was consumed to add 4% of ash to the entire product. In nearly all cases the increase of ash due to the burning of coke is conspicuous.

The theoretical yield of the coke can be determined within a fair degree of exactness from the proximate analysis of the coal. The coke carries all the ash and fixed carbon, and, even under the best work, a certain portion of volatile matter and moisture. The sulphur will probably be distributed in the coke, as indicated in the analysis. In other words, a coal of the following composition: Moisture, 1.25; volatile matter, 26.30; fixed carbon, 66.05; and ash, 6.40; total, 100—may be expected to give a theoretical yield of 66.05 + 6.40 = 72.45% of coke. To this should be added at least 1% for the moisture and volatile matter, which are retained by average "good coke," so that the theoretical yield of coke made from the above coal can be assumed to be 73.45%. Dividing the fixed carbon, ash and 1% of moisture and volatile matter by that figure, we would get, for the coke made from this coal: Fixed carbon, 89.92; ash, 8.71; volatile matter and moisture, 1.36; total, 99.99.

In carefully burned ovens,the ash should not be increased or the carbon reduced by more than 0.5% from the figures obtained by calculations like the above, and the volatile matter and moisture may both be reduced from the above figures, though they are often greater. There are various modifying factors, the exact measure of which cannot be accurately determined. Among these is the deposit of carbon from decomposition of the gases. The amount of ash is inversely proportional to the yield, so that increase in the yield at the same time decreases the ash. It is not uncommon to claim an advantage from an increase in a coke, up to a certain point, of ash of suitable composition, as a means of hardening the structure; but I suppose no one will claim any advantage from the ash which does not form part of the structure, but is simply derived from outside sources, either by collection or otherwise. This latter ash is simply paid for as coke, and then must be got rid of. It must not be confounded with that which enters into the structure.

After the coal goes to the ovens, there are several ways in which the ash in the coke produced may be increased above the theoretical amount. A portion may be derived from the dirt filling around the trunnel head; a portion from forking the coke from a dirty yard; a small amount from the impure water used in quenching; but by far the larger amount comes from the ashes of the coke burnt up in the oven. As the latter is almost in reverse proportion to the yield, it is obvious that the advantage of yield is not confined entirely to the saving of coke, but goes hand in hand with improved quality.

The "commercial" yield will be determined by local conditions, and the character of the particular coal. It is the theoretical yield, less the losses in burning and of fine coke in handling, and increased by the ashes and dirt gathered as noted above.

In good coking coals, high in volatile matter, the "breeze" or fine coke will run 2 or 3%, and the commercial yield should not be more than from 3 to 5% below the theoretical. It is possible to do better, but anything not so good may be considered bad practice. With higher fixed carbon in the coal, and particularly when the coal is low in ash, and will burn or "cut" readily by small leaks admitting air, the difference between the theoretical and the commercial yield may be between 5 and 10%; but first-class work should approximate the former figure.

The question of yield is involved to a greater or less extent in all the operations connected with handling the coke ovens. The conditions which permit of the greatest regularity of drawing and charging, in which the leveling is done as it should be, the ovens are watered down to the best advantage, and are worked to their capacity, etc., are all factors affecting the yield. A plant in which the discipline and management is good will naturally have a better yield than where the management is lax; but after all this is said, there still remains the difference due peculiarly to a special effort, or want of effort,, in the way of handling the draft and the oven with special reference to this point.

The principal thing which affects the question of yield is the care and skill with which the drafting, or admission and exclusion of air to the oven, is controlled.

The object and purpose of the drafting is to secure a satisfactory degree of heat at the right time, and as nearly as possible to secure this heat from the gases which are driven off during the process of coking, and which would otherwise be entirely wasted. The more nearly it is possible to completely burn out the coke at a satisfactory temperature, and leave the ovens in first-class condition for the next charge, without burning any of the coke which has been formed, the more nearly do we attain perfect results. The mistake is commonly made of assuming that at all stages of the process, whatever may be the condition of the oven, an increase of draft means an increase of temperature and a decrease of draft a decrease of temperature. The most casual examination will show that this is not the case. At the first stage of the burning, before the gases which will add to the heat by their combustion have commenced to come off, it is possible to cool the oven by excessive draft; and it is common and advisable practice to cover the ovens immediately after drawing, and recover them after charging, with a view to their "catching-up" more rapidly. By this means the heat stored in the walls finds its way to the inside of the oven. There is apt to be a time, within the first 12 hours after an oven has "caught-up," when the amount of gas formed is in excess of the ability of anything like an ordinary draft orifice to furnish the necessary air to retain the oven at a temperature for perfect combustion. During this time, also, the trunnel head of ordinary size has great difficulty in disposing of the products of combustion. Later in the process, this condition is reversed, and the amount of air is apt to be in excess of what is necessary to burn the gases which are coming off; and, finally, if the draft is not changed, it becomes greatly in excess of the requirements of the ovens. From this stage to the end of the burning it is thoroughly possible for an oven to continue to cool, even with the admission of a large volume of air. In other words, the heat furnished by the small amount of gas which is coming off, and from the consumption of a portion of the coke, is less than the lowering of temperature caused by the loss of heat from the trunnel head and from radiation; and this difference is increased by increasing the draft. The attempt to hurry an oven which has been allowed to cool, and which is continuing to cool, while exhibiting a number of "candles," by giving to it an excess of draft, is often indulged in; but it will be found very much better to endeavor to burn the oven so as to keep the heat up to a maximum towards the end of the blast, at the time when it is needed most to reach the coal at the bottom of the oven, rather than to try to replace the heat by an effort to burn a portion of the coke. This effort is always disappointing in results. As a general proposition, I should say that, in nine times out of ten, the drafting is too heavy, and the oven can be brought out in better shape by a more uniform drafting extending over a longer period. As a rule, from 20 to 25 sq. ins. in the form of a circular draft at the top of the door (which may be as much as 40 ins. high), will be ample for the largest oven which it may be desirous to burn out, while this should be reduced by at least one, or possibly two, changes as the oven is burnt out, so that the amount of air shall at no time be greatly in excess of what is necessary to completely and clearly burn off the escaping gas.

As a rule I should say that the tendency is to make the trunnel heads too large. Of course, they have to be large enough to take with sufficient promptness the coal from the larries; but the standard forms of larry will readily discharge into an opening 12 ins. in diameter, and I have never yet seen an oven or a coal which would not give better results with an orifice of that size, than with a larger one. Yet larger sizes are common. I know of one manufacturer whose standard size is 16 ins., or nearly twice the area of a 12-in. trunnel head. The latter is abundantly able to carry off, under the best conditions of drafting, the products of combustion; and any excess above this very materially increases the loss of heat, and interferes with the efficiency of the oven.

The small-sized opening may be slightly inadequate at the beginning of the blast; but as the gases come off in smaller quantity and more slowly, it is invaluable in retaining the heat so much needed at the latter stage. The smallest trunnel head I have tried for a 12-ft. oven was 11 ins. in diameter; and the results were fairly good. The ordinary difficulties connected with prompt charging limit the size to 12 ins. and upward, and I believe that the smallest size that can be readily handled by the charging facilities will be found the best.

The use of lids is extremely desirable. Properly handled, they mean a great deal as regards the matter of yield. The retention of heat in the oven is, of course, of the utmost importance. The ovens should be covered as soon as drawn. They should be covered when charged until they are "caught up;" and as soon as the oven is practically burnt out, the draft should be cut off entirely, and the trunnel head partially or entirely closed. This will aid in retaining the ovens in the best possible condition, and will prevent the burning up of a large amount of

*A paper read before the American Institute of Mining Engineers, October, 1902.

†Chemist, Geologist and Mining Expert, Staunton, Va.

Form for Monthly Efficiency Record of Coke Ovens.

	Tons.		Yield in coal used, per cent.			No. of ovens drawn			Coal charged per oven. Tons			Monthly efficiency record, %
	Coke made.	Coal used.	Theoretical.	Practical.	Actual.	Efficiency.	Possible.	Actual.	Efficiency,%	Possible.	Actual.	Efficiency,%	
January, 1902	8,911.65	13,957.00	75.95	67	63.85	95.30	3,405	2,925	85.93	5.25	4.77	90.85	74.39
February	8,565.10	13,215.70	77.59	67	64.81	96.73	2,995	2,985	99.66	5.25	4.42	84.19	81.15[5]
March	9,107.05	14,251.80	77.38	67	63.90	95.37	3,575	2,888	80.78	5.25	4.93	93.90	72.33
April	8,853.20	14,403.55	77.30	67	61.46	91.73	3,416	2,910	85.18	5.25	4.95	94.28	73.67[5]
May	9,341.65	14,821.6	74.7	67	63.02	94.06	3,455	3,032	87.75	5.25	4.88	92.95	76.72[5]
June	6,977.85	10,803.8	77.1	67	64.58	96.38	3,057	2,689	87.96	5.25	4.18	79.61	67.49[5]
July	5,506.45	8,448.4	75.0	67	65.20	97.31	1,812	1,644	90.72	5.25	5.33	101.52	89.62[5]

[1]More 48-hour coke was made than 72-hour coke.
[2]The loss was in burning the coke overtime.
[3]The loss was in small charges.
[4]The charges for the ovens are too small.
[5]All departments in coke manufacturing increased in efficiency, hence the good result.

coke. Particularly should the doors and jambs be kept tight, and the smallest cracks stopped. The consumption of coke from this cause is enormously larger than would be supposed at first sight.

It is almost impossible to make any improvement in the matter of yield without keeping records in such shape as to show what are the good or bad results of any method of treatment. It is absolutely necessary, therefore, that arrangements be made to calculate, from either the railroad or the larry weights, to within at least 0.25% of the actual yield, within one or two days from the end of each month. With this, there is the strongest incentive to endeavor to improve; and without it, there is the strongest reason for making no change, since it cannot be known whether a change is advantageous or not. It is impossible to give a form for such a record, because it will vary with each plant; but I would call attention to the fact that that portion of the coke and coal on the yard or in bins, or in transit at the beginning and end of each month, if carefully estimated, cannot introduce a large error; and any such error which is made one month is balanced in the succeeding months; so that, if actual weights be taken of the coal that goes to the ovens and the coke that is shipped away in each month, the other amounts being estimated, the results will be very close.

I submit the accompanying form as a valuable one for keeping the monthly record and comparing the work month by month. It is a copy of a report from a plant in actual operation.

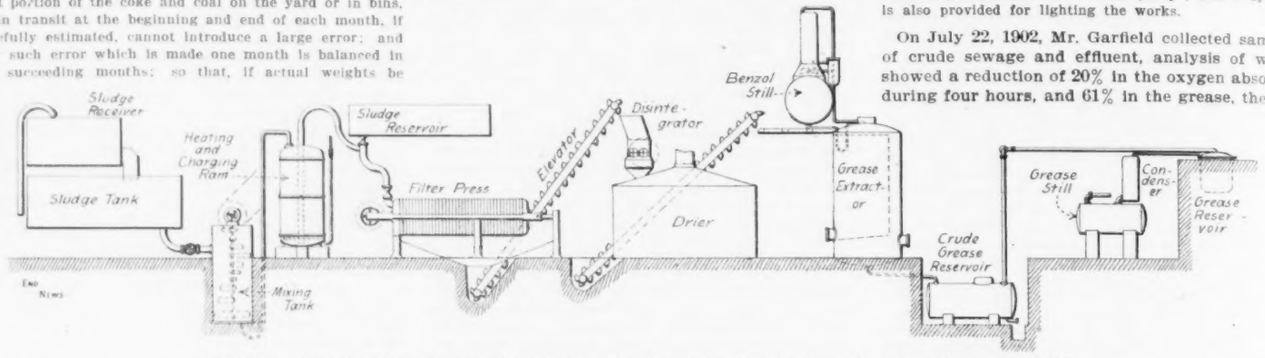
The monthly efficiency record will be found by multiplying the efficiency per cent. of yield; the efficiency per cent. of coal; and the efficiency per cent. of the number of ovens drawn, and will no doubt astonish some coke-makers when they apply this form to their own operations. The theoretical yield is determined as explained above; and the practical yield is somewhat smaller, depending on the tendency to make fine materials or "breeze," the composition of the coal, the condition of the ovens, and equipment, etc.

A SEWAGE SLUDGE REDUCTION PLANT AT CASSEL, GERMANY.

An interesting experiment on the utilization of sewage sludge at Cassel, Germany, was begun early this year under a 20-year contract between the city and the Engineering Co., of Cassel. In brief, the sludge is screened, acidified, heated, pressed, disintegrated, dried, and then the grease is extracted with benzol and subsequently refined. The process in detail is described by Mr. J. Garfield, Assoc. M. Inst. C. E., Sewage Works Engineer of Bradford, England, in a special municipal report made after a visit to the Cassel plant during the summer of 1902. From this report, as published in the London "Contract Journal" for Oct. 8, 1902, we abstract the following:

Cassel has a population of about 106,000, of which 100,000 is connected with a sewerage and sewage disposal system put in operation early in 1898. The sewage is almost wholly of domestic origin, with the exception of portions of the liquid wastes from two works, where tin is extracted from scrap iron. The daily flow of sewage is about 3,165,000 (U. S.) gallons, of which one-tenth is pumped. The sewage is treated in five settling tanks, 13 × 130 ft., × 10 ft. deep, with a total capacity of 630,000 (U. S.) gallons, or about one-fifth of the average daily flow. The tanks are operated on the continuous flow plan. No chemicals are used, but the acid in the sewage from the tin recovery works may aid deposition. The sewage is screened before it leaves the tanks, and is then discharged into the River Fulda, without further treatment. The composition of the crude sewage and effluent, in parts per 100,000, is given as follows:

	Crude Sewage.	Effluent.
Suspended matter	854.5 (85.45?)	24.00
Sulphuric acid (combined)	10.30	12.70
Chlorine	11.20	10.00
Ammonia	13.84	12.15



GENERAL ARRANGEMENT OF SEWAGE SLUDGE TREATMENT APPARATUS AT CASSEL, GERMANY.

Up to February, 1902, the sludge was discharged onto land adjoining the works, but owing to previous complaints treatment by the method already outlined was begun at or about that time. The agreement with the Engineering Co. provides that the city shall deliver the sludge into tanks provided by the company, and that the latter shall dispose of the sludge, without causing a nuisance, for a period of 20 years. So far as stated, the company receives no bonus from the city. Some 300 to 450 tons of sludge, with about 90% of moisture, are treated each week. Credit for the method of sludge disposal adopted is given to Dr Paul Degener, "a chemist of repute, now deceased." The process is covered by English Patent No. 21,856, dated 1901. The plant is described by Mr. Garfield as follows (see illustration also):

To produce the pressed cake from this sludge the company have erected filter presses of the usual type. Before being discharged into the presses the sludge is screened, acidified with sulphuric acid, and heated to 100° C. The operation of pressing requires a considerable time, the presses being filled and emptied once in 12 hours. The sludge cake produced is good, but has rather an offensive odor. It is at once passed into a distintegrator, where it is broken up prior to being finally dried in a steam-heated drying apparatus. This apparatus consists of two cylinders, one inside the other, through which the cake passes in succession. The cylinders are heated externally by exhaust steam, and internally by a series of pipes carrying scrapers. These pipes, which are made to revolve, are supplied with steam from a boiler. In this machine the moisture in the cake is reduced to about 15%, and the process of drying is said not to cause a nuisance. From the drying apparatus the cake is discharged direct into the "extractor," for the recovery of grease, of which it contains some 15%. The extractor is cylindrical in form, and vertically arranged. To charge the extractor a cover on the top is removed and some five (long) tons of dry cake are filled into an inner cylinder communicating with the outer one through an opening covered by a filter cloth arranged near the bottom, the bottom of the inner cylinder being some distance above that of the outer one. The cover being replaced, heated benzol is allowed to flow through the cake, passing downwards and into the outer cylinder through the filter cloth. Here it is distilled over, the vapor rising between the inner and outer cylinders to a condenser arranged above the extractor, from which it again flows into and through the cake, taking up more grease. This operation is repeated three times, after which the cake is said to be free from grease. From each charge of cake some 1,760 lbs. of crude grease are obtained. One thousand three hundred and twenty gallons of benzol are used, 1% of this being lost in the operation. Petroleum spirit (benzine) has also been used with equally good results. The residue which is removed from the bottom of the extractor consists of a dry powder, containing about 3% of nitrogen, and is readily sold as a manure. The crude grease is black and contains some water. It is passed into a separator, where, with the aid of heat and compressed air, the water is driven off. From this separator the grease is passed into a still, where it is heated in vacuum by direct fire and superheated steam. Seven (long) tons of crude grease produce five tons of distillate and one ton of tar; the difference of one ton being water, and a little gas, which is burned under boiler furnaces. The distillation of one ton of grease is said to cost from $1.60 to $2.40. To obtain a perfectly white grease, the first distillate, which is light brown in color, is again distilled, but this in practice is not of advantage commercially. The grease obtained is sold for soap and candle making at $92.50 per (long) ton, and the manure is valued at $8 per (long) ton. The motive power used consists of a steam boiler, with 1,620 sq. ft. heating surface, a 35-HP. steam engine, air compressor and vacuum pumps, and three water pumps; and a dynamo is also provided for lighting the works.

On July 22, 1902, Mr. Garfield collected samples of crude sewage and effluent, analysis of which showed a reduction of 20% in the oxygen absorbed during four hours, and 61% in the grease, the latter being reduced from 18 to 7 grains per Imperial gallon. Samples of the sludge cake "before and after degreasing" gave the following analytical results, also in grains per Imperial gallon:

	Before.	After.
Moisture	39.4	8.2
*Grease	9.0	1.0
†Nitrogenous compounds	15.05 }	98.80
Other matters	36.55 }	
	100.00	100.00
*Grease in dry solids	14.8	1.09
†Containing nitrogen	2.38	

Refining the crude grease reduced the moisture from 18.8 to 1.44%, and the unsaponifiable matter from 14 to 7.20%; and increased the saponifiable grease from 67.2 to 91.36%. The final tankage, or manure, had the following percentage composition:

Moisture	6.80
*Grease	2.00
†Nitrogenous compounds	15.43
Other solids	75.77
	100.00

*Grease in dry solids, 2.14%. †Equal nitrogen, 2.45%.

The estimated cost of a sludge treatment plant capable of treating 15,000 long tons of sludge per year (amount and character about the same as at Cassel) is put by the company at about $50,000 for construction and some $20,000 a year for operation and capital charges, giving an estimated profit, above interest and sinking fund, of some $2,000 a year.

As Mr. Garfield states, the sewage of Cassel cannot be said to be purified, and it remains to be seen whether the process of sludge treatment will prove to be a commercial success. An attempt made some time ago, to filter-press Bradford sludge after heating it with sulphuric acid proved "to be expensive and difficult on account of the large proportion of grease." The grease was nearly all removed from the Cassel sludge, which, it may be added, greatly increases the availability of the tankage for manurial purposes.

CONCRETE MIXING AND HANDLING MACHINES FOR THE GALVESTON SEA-WALL.

After the city of Galveston, Tex., had recovered from the disastrous effects of the great storm and flood of September, 1900, a board of engineers was appointed to investigate and report upon means of protecting the city from future inundations. The report, which was published in our issue of April 24, 1902, recommended the construction of a concrete sea-wall and the raising of the grade of the city along the water front by filling in behind the wall. This recommendation was adopted, and the contract for the building of the wall has been awarded to J. M. O'Rourke & Co., of Galveston, Tex. The wall will be about 3½ miles long, 16 ft. high, and 16 ft. wide at the base, with a curved face. The contract covers about 127,000 cu. yds. of concrete work.

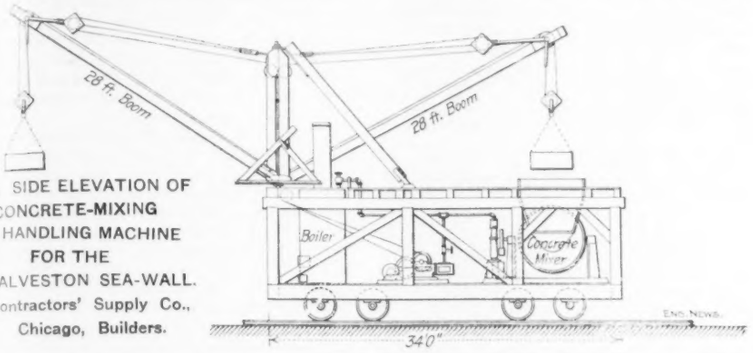


FIG. 1. SIDE ELEVATION OF CONCRETE-MIXING AND HANDLING MACHINE FOR THE GALVESTON SEA-WALL. Contractors' Supply Co., Chicago, Builders.

For the prompt and economical execution of the work two concrete-mixing and handling machines have been built to special designs. One of these is shown in the accompanying cuts, Fig. 1 being a side elevation, and Fig. 2 an end elevation, which also shows its position in relation to the wall and the material supply tracks. The machine consists of a double-deck car, 34 × 16 ft., carried on eight wheels; the boiler, engines and concrete mixer are on the lower deck, while the operating platform is on the upper deck. At the front end of the car are two derricks with 28-ft. booms, each revolving through 270°, and each operated by its own attendant; one handles the raw materials, and the other handles the concrete in 1-yd. batches. The materials are loaded from cars into skips and dumped upon the upper deck, from which they are delivered in measured quantities to a No. 3 Smith rotary concrete mixer (Eng. News, May 2, 1901) on the lower deck. After mixing, the machine is tilted so as to discharge the batch of concrete into a skip, which is then swung and dumped by the second derrick. Each machine has a capacity of 300 to 350 cu. yds. per day, but it is expected that the daily work will average 500 to 600 cu. yds. with both machines.

The hoisting and swinging movements of the derricks are effected by power, and each derrick is operated by its own 12-HP. horizontal engine. A 16-HP. vertical engine drives the mixer. Steam is supplied by a 50-HP. vertical, submerged flue boiler, with shell 5 × 9 ft. The car can pull itself ahead as required by hauling upon anchored cables, the ends of which are wound round winch heads on the hoisting engines. The concrete mixer was built by T. L. Smith, of Milwaukee, Wis., and the hoisting engines and derricks were supplied by the Lidgerwood Mfg. Co., of New York and Chicago.

The complete machines, with their equipment for handling and mixing concrete, were designed by Mr. C. W. Speece, General Manager of the Contractors' Supply Co., 1531 Monadnock Block, Chicago, and this company has the contract for their construction. A smaller Smith concrete mixer, mounted upon a truck, will be used for certain auxiliary work, and for filling in gaps which will be left in the wall at intervals during construction.

A WATER SUPPLY FOR HYDRAULIC MINING AT THE BRISEIS TIN MINES, TASMANIA.

A water supply development for hydraulic sluicing at the Briseis tin mines in Tasmania possesses a number of points of interest which we extract from a description of the whole work read before the Victorian Institute of Engineers, at Melbourne, Australia, on Aug. 6, by Mr. H. V. Champion, Consulting Engineer to the Briseis Tin Mines, Limited. Two canals, coming from different sources of supply bring the water to "head tanks" near the mines. The Rongarooma canal, heading in a river of the same name, is about twenty miles long, and the Maurice canal, which brings water from Maurice River to Dunn's Creek, is about ten miles long. A low dam of decomposed granite, with a puddle wall of clay below, and selected and rammed decomposed granite above the natural surface, directs water from the Rongarooma River. Across Maurice River and its branches there are four low dams of loose stone, with a center wall of parallel logs, three at the bottom, two above and one at the top, having squared ends "fastened together with dumbolts." The dam across Dunn's Creek is built of half-ton stone. Its up-stream side is battered 1 on 1 and its down-stream side is in steps 3 ft. high and wide, with 18-in. logs anchor-bolted to the dam and forming the angles or nosings of the steps. None of the dams mentioned are over 15 ft. high. All the stone dams have passed two floods without injury. They are made water tight by sand and silt carried by the water. The canals, using the word broadly, include ordinary earth channels; earth embankments; reinforced by dry masonry, on steep ledges of rock; timber flumes; and inverted steel siphons. Some of the channels in earth are lined with rough stone and some of the side-slope construction, on loose, rocky material, is lined with vertical planking. For the trestles supporting the timber flumes round timber was used, with sawn braces. On the Rongarooma canal there were two 40-in. and two 38-in. steel inverted siphons, with an aggregate length of about two miles. The pipe was riveted longitudinally, but its circumferential joints were made by riveting on hubs and spigots and calking with lead. The plates, joints and rivets were imported from America, and the pipe was shaped and riveted in Tasmania by Mr. Mephan Ferguson, an Australian (Melbourne?) contractor. The pipe was coated with Trinidad asphalt and coal tar. The works outlined above "were designed and carried out by Mr. Donald Fraser, brother of Mr. J. H. Fraser, C. E., of Melbourne University."

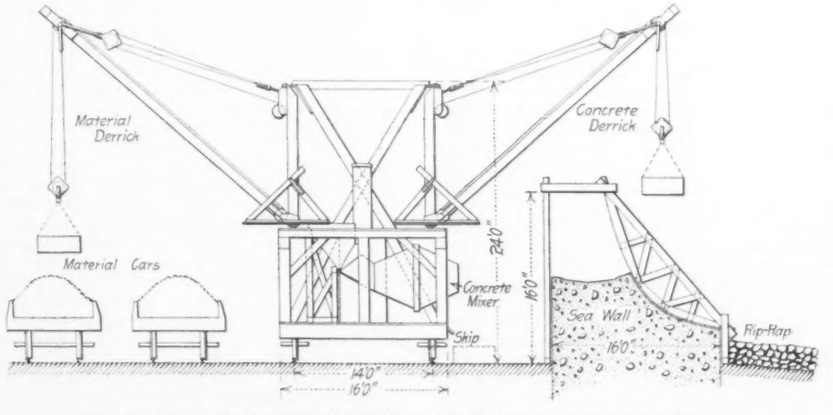


FIG. 2. END ELEVATION OF CONCRETE-MIXING AND HANDLING MACHINE.

THE COST OF CRUSHING STONE AT BARABOO, WIS.

By W. G. Kirchoffer, C. E.*

The cost of crushing quartzite rock by our municipal crushing plant during the past two years, at Baraboo, Wis., and other details are as follows:

The plant was moved from the location of last year to one which seemed more desirable on account of quarrying the rock; but the foreman of the quarry refused to use the steam drill, and consequently used more dynamite, so that the total cost of crushing was not materially reduced by the change of location. Also, the dies for the crusher were made by a home man, and did not last much longer than two days to a set.

About 10% of screenings were screened out of the stone; and a good quality of clay was used as a binder.

The crusher was about 12 × 16 ins. in size, and gave a daily output of 53 cu. yds.

Items.	Cost 1901. Total for each item.	1901. Per cu.yd.	1902. Total for each item.	1902. Per cu.yd.
Stone in quarry	$76.80	$0.04	$100.00	$0.027
Improvements*	27.05	.014	87.25	.0236
Depreciation of crusher.†	89.84	.0467	169.02	.0456
Steam drills.‡	50.65	.0264	.....	...
Picks, shovels, etc.§	53.90	.0281	38.85	.0104
Dies for crusher	128.00	.0677	396.00	.1069
Freight on supplies	33.72	.0175	3.61	.0009
Fuel for engine.¶	134.56	.0744	173.58	.0468
Oil	6.00	.0031	23.00	.0062
Dynamite, 24-27 cts a lb.	100.77	.056	407.24	.1099
Supt's. horse and liveries	34.00	.0177	94.06	.0253
Superintendent crusher.	131.50	.0685	228.20	.0615
Labor quarrying stone and tending crusher.	1,372.85	.714	1,983.03	.5354
Rent of engine	163.93	.0854	245.00	.0661
Water boy	.....	...	30.85	.0083
Hauling water; supplies.	.....	...	73.75	.0190
Supplies	.....	...	42.13	.0113
Superintendent of quarry	.....	...	285.60	.0771
Hauling stone to city	960.00	.50	1,801.75	.50
Total cost	$3,363.57	$1.752	$6,182.76	$1.67

*Permanent (bins, etc.), 20% of total first cost.
†10% for 1901; but for 1902, actual cost.
‡20% of $218) + $7.00 = $50.65.
§50% of first cost.
¶At $4.00 per ton.
Note.—The total cost includes stone delivered on street.

The wages, etc., paid were as follows: Wages, per hour for laborers, 15 cts.; for quarrymen, 17½ cts.; for drill runner, 20 cts.; for engineer and engine, 35 cts.; for team with driver, 30 cts. The cost per ton of coal for engine was $4.60 delivered; and the crusher engine boiler supplied steam for the drill. The price of 60% dynamite per lb. was 24 cts., and for 70% dynamite, 27 cts. (for 1902). One pound of dynamite blew out about 4 cu. yds. of stone on an average. The average length of haul from crusher to point of delivery was, in 1901, two miles; in 1902 it was 2½ miles.

The stone was measured in the wagon, which was built to hold just 1½ cu. yds. by weight (3,900 lbs.). We crushed 1,920 cu. yds. in 1901, and 3,700 cu. yds. in 1902.

*Consulting Engineer, Baraboo, Wis.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter. Published every Thursday at St. Paul Building, 220 Broadway, New York, by

THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, - - - - MANAGING EDITOR.
F. P. BURT, - - - - - - - - BUSINESS MANAGER.

M. N. BAKER, CHAS. S. HILL, - - - - } ASSOCIATE EDITORS.
E. E. R. TRATMAN, F. E. SCHMITT, - - - - } ASSOCIATE EDITORS.
WM. KENT, H. P. GILLETTE, - - - - } ASSOCIATE EDITORS.

CHAS. W. REINHARDT, - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston,
ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; *6 months,* $2.50; *10 weeks,* $1.00. *To all other countries in the Postal Union: Regular Edition, One Year,* $8.00; *Thin Paper Edition, One Year,* $3.75. *SINGLE COPIES of any number in current Volume,* 15 *cents.*

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 323 *means that subscription is paid to the* 32d *week (that is the issue of Aug.* 6) *of the year* 1903; *the change of these figures is the only receipt, unless one is sent by special request.*

ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

We give up much space in this issue to a very interesting paper which is to be read at the forthcoming annual meeting of the American Ceramic Society on the elimination of hand labor in brick manufacture. The system described in the paper has been put in practical operation in a large brickmaking plant at Dover Point, N. H., and is reported to be working with entire success.

No figures are given as to the reduction in cost of manufacture effected by the system, and even if they were given they would hardly be conclusive, since any such revolutionary invention must be judged by its inherent possibilities rather than by what is actually accomplished in the first plants built. We see no reason why the system should not effect a large reduction in the cost of brick manufacture, particularly in locations where the material at hand and the market available permit production to be conducted on a very large scale.

Engineers are familiar with the marvellous economies which have been effected in such industries as steel production and cement manufacture, by eliminating human muscle in the handling of material. There is no reason to doubt that a large decrease in the cost of brick manufacture may be made on similar lines. The effect of a large reduction in the cost of brick upon such industries as brick paving or the construction of sewers, arches, buildings and the many other classes of construction for which brick is used is obvious to anyone. Engineers will watch with interest the progress of this notable advance in brick production.

We print elsewhere that portion of Gov. Odell's message which relates to the proposed 1,000-ton barge canal. If the majority of the New York legislators are no more favorably disposed toward this enterprise than the Governor appears to be, it is likely to fare no better than in previous years. The Governor shows that while New York and Buffalo are strong advocates of the 1,000-ton barge canal, the sentiment in the interior of the State is strongly opposed to it. He calls attention to the fact that although canal rates are far below railway rates, freight goes by rail and not by canal, and he suggests the question whether this will not continue to be the case after the canal is improved at an enormous cost. "Will an enlarged canal win back the commerce we have lost?" asks the Governor, and he continues:

> The inability to use the canal for at least five months of the year, in addition to the terminal charge at New York and the breaking of bulk at Buffalo, seems to give the railroads an advantage which should be thoroughly considered before an enlargement of the canal is authorized.

As we read this, the Governor joins in the approval of the barge canal project only because of its support by influential commercial and political organizations. As a business man he is yet to be convinced that the venture will be a financial success, and he turns the responsibility for a decision upon this point over to the legislature.

As for the matter of route, recently discussed in these columns, the Governor states that his prepossessions were for the route which Engineering News has favored, that by Lake Ontorio. Since the canal promoters have united in declaring that they will have the inland route or nothing, the Governor accepts the situation and says that in balancing the cost of the enterprise against its expected benefits, the cost assumed must be that of the expensive interior route. This he places at the enormous sum of $255,000,000, by adding to the engineers' estimate the interest payments at 3% for 50 years, and allowing 20% increase as a margin of safety, since to quote from the message:

> It is well known that no great undertaking of this character was ever completed within the engineers' estimate; but owing to the increase in the cost of labor and of material there should be a factor for safety of at least 20% more.

If the Governor would examine the work done by engineers elsewhere than on the public works of New York State, he could easily find cases where works of very large magnitude have been carried out within the engineers' estimate. The allowance for increased cost of labor and materials since the engineers' estimates were made, however, is a proper one. As for the inclusion of the interest payments in the estimate of total cost, the fact that the canal is not expected to return any direct revenue to the State does give an excuse for this. It is certainly misleading, however, and cannot be commended as a model for accountants or statisticians.

In discussing this subject several months ago, we warned the advocates of the barge canal project that their insistence on the costly interior route would ensure the defeat of the project. It is now apparent that it has alienated the support of Gov. Odell. Reading between the lines of his message it is not difficult to gather that a barge canal on the Ontario route, which could be built at a cost of some $45,000,000, would have commanded his support, while toward the more costly project he is at best neutral.

We shall not again present the arguments in favor of the Ontario route, which were given in our issues of Sept. 11 and Oct. 2, further than to repeat that if a 1,000-ton barge canal from the Lakes to tidewater is to cost as much as $80,000,000 to $100,000,000, it would be far better for the State and for the nation to build the larger waterway, 21 ft. in depth, for which surveys were made by the U. S. Deep Waterway Commission. In a later issue we hope to present some further data in support of this proposition.

Concerning the recent head collision at Wanstead, Ont., on the Grand Trunk Ry., we find a published statement, purporting to be officially given out by the General Manager of the railway, and we quote from it as follows:

> So far as we can ascertain no superior officer of the road is to blame. It is simply one of those inexplicable accidents in which the human mind has been lacking. The material loss of property will not exceed ten or fifteen thousand dollars, but the company expects it will have to face a loss of a quarter of a million by the time all the claims have been settled.

The sequence of events which led up to the disaster are of interest as indicating whose human mind was lacking. The stations between which the confusion of orders occurred are shown below. They were spaced about four miles apart.

W. Wyoming—Wanstead—Kingscourt—Watford, E.

An express train was running west and a freight train east, the former an hour behind time. The dispatcher ordered train order signals displayed for the express at Watford and for the freight at Wyoming, and sent duplicate orders for the trains to meet at Wanstead, both orders being correctly repeated back by the operators, as required by the standard code of rules. The freight arrived at Wyoming, but had some trifling delay in getting away, which was reported by the operator there to the dispatcher. The operator at Watford then reported to the dispatcher that the express was approaching his station and the dispatcher, having in mind the delay of the freight at Wyoming, replied: "May bust it," meaning that if further reports of delay came from Wyoming he might hold the freight there and let the express proceed. The Watford operator, however, had of course overheard the Wyoming message of the delay to the freight and he failed to catch the first word, "may," of the dispatcher's message to him. He took this "bust it" as a cancellation of the meeting order of the express, and so reported to the conductor of the express, when it stopped at his station. The express at once pulled out. Meanwhile the Wyoming operator reported to the dispatcher that the freight was leaving, and the dispatcher replied "Let her go." He then called the Watford operator, who reported, to the dispatcher's consternation, that he had canceled the express train's meeting order and that that train had gone.

The dispatcher at once endeavored to prevent the disaster and called to Wyoming to stop the freight, but the operator replied, "I can't." It appeared that the freight was just leaving the yard limits, and the operator's signals in the hope of attracting the attention of the rear brakeman were unavailing. Finding it impossible to stop the freight, the dispatcher tried to stop the express at Kingscourt. This is a junction point. A night operator was on duty and there seemed no reason why the express might not be stopped at this station and the impending collision prevented. But the night operator at Kingscourt was a boy of 16, and he testified as follows, according to a dispatch to the New York "Tribune":

> He was on duty for the first time on the night of the accident, and his total previous experience as an operator was for two nights at Strathney, where he received only a total of four messages. He gave as a reason for not hearing the dispatcher calling him for seven or eight minutes that he was studying the time table and did not recognize the office call, which he had heard only once before.

Thus this boy of 16 sat in his chair and heard a trainload of passengers ride past him to destruction, while all the time the dispatcher at the other end of the wire was calling on him to save them. Thus, these men and women had their lives hung in the balance against the ability of a boy of 16 to recognize a signal on a telegraph sounder which he had heard only once before.

This is the situation referred to in the official statement as "one of those inexplicable accidents in which the human mind has been lacking." We agree that a lack is shown, but was the lack greater in the inexperienced and incompetent boy or in the higher official who placed such responsibilities upon him?

Again, the operator at Wyoming had no business, under the standard code, to cancel a train order issued in any such irregular way as the mere "bust it" message which he claims to have heard; and had he even repeated it back to the dispatcher, as the rules require, the mistake would have been discovered and the accident prevented. But how much blame shall we award to him and how much to the system which leaves such opportunities for error open? It is true that the accident may be ascribed to the neglect of the precautions which are prescribed for operating trains by telegraphic orders; but we cannot overlook the fact that a system which requires such precautions betrays its inherent defects thereby. The fact is that these precautions are too often neglected in the rush and hurry of every-day railroad work

on many roads; they are felt to be in the nature of red tape, and it is difficult to impress upon trainmen and station operators the necessity of carrying them out in any other than a perfunctory manner.

We print in this issue a paper by Capt. H. C. Newcomer, U. S. A., on the stresses developed in a wire rope due to the bending of the wires as they pass around a drum or sheave. The author says in a personal letter that he desires discussion and criticism from engineers who have had experience in the use or testing of wire rope as to the correctness of the rules and formulas which he proposes.

We may suggest in connection with the first formula assumed by Captain Newcomer, that a question may be raised as to its applicability. The formula is unquestionably correct for a beam supported at both ends, but is it equally applicable to a bent wire supported continuously by a drum until it reaches a point of tangency? Does not the support given by the drum surface act to complicate the problem?

But even granting that we are justified in applying the common formula for bending stress in extreme fibers, are we justified in adding the unit bending stress in extreme fibers, to a unit stress determined by dividing the total direct load by the sectional area?

Calling tension stresses +, and compression stresses —, we have + stresses on the convex side of a bent wire and — stresses on the concave side; we also have + stresses due to the direct load on the wire.

Are we justified in adding the extreme + stress due to bending to the unit + stress due to direct loading, to obtain a total extreme unit stress? If we do, we virtually assume that the fibers act independently in supporting the load, an assumption which seems at least doubtful.

We shall be pleased to hear from any of our readers who can furnish reliable data as to the influence of bending upon the strength of wire ropes.

We would call attention also to two excellent articles on wire rope that were published some time ago in Engineering News: the first by Mr. A. S. Biggart appeared in our issue of Jan. 17, 1891; the second by Mr. William Hewitt, Vice-President of the Trenton (N. J.) Iron Co., in our issue of May 7, 1896.

Mr. Biggert gave the results of numerous experiments upon the wear of wire rope using sheaves of varying diameter; while Mr. Hewitt discussed the stresses developed in wire rope, and the horse-power transmitted. Mr. Hewitt also considered the effect of the spiral winding of the wires in the rope as a factor in reducing the stress due to bending the rope around a sheave.

THE RESISTANCE TO TRACTION OF SMALL MINE CARS.

There is a great array of published matter relative to the frictional or tractive resistance of large cars on modern standard gage railway tracks; but very little is to be found as to the rolling resistance of small cars on narrow gage tracks, such as are used in mines or by contractors in earth and rock work.

The engineer need not be told that the force required to pull a ton on wheels over a level track varies greatly according to conditions of track, car construction and car loading; but in estimating the size of small locomotives, tail-rope engines and the like, we very frequently see assumptions made as to car resistances that are altogether too low, because they are based upon experiments made under entirely different conditions. To the practical man who is not an engineer, all tracks and all cars look alike, so far as rolling resistance is concerned. He reads that tests have shown that a pull of 6 lbs. per ton will move a freight car on a railway track, and forthwith he concludes that a like force per ton will move a mine car. The practical man thinks that this ease of rolling on a track is due entirely to the smoothness and hardness of the steel rail. He does not realize that the low resistance is due almost entirely to the rigidity and cleanness of the rail, by virtue of which the car wheels are not continually traveling up a steep hill, or over small, irregular, constantly recurring bumps. The smoothness of the rail of course does away largely with the bumps and irregularities that exist in a wagon road, but we shall presently see that it is the rigidity and slight bending under load that make the best tracks so easy to pull loads over.

Tests by the late A. M. Wellington on freight cars showed that on a level track at a speed of 10 miles per hour, it required 5 lbs. per ton to pull a loaded car and 7 lbs. per ton to pull an empty car; whereas it required 14 lbs. and 18 lbs. per ton to start the empty and the loaded cars, respectively. With higher velocities, the friction of the air rapidly increases the resistance to traction, but we need not consider this factor in mine haulage.

In Porter's catalogue of light locomotives for contractor's use we find the following:

Items.	Resistance per short ton. lbs.
Extra good cars and track	5
Average first-class cars and track	6½
Reasonably good cars and track	8 to 12
Logging cars, first-class	6½ " 15
Logging cars, poorly oiled	20 " 40
Street cars	15 " 25
Contractor's dump cars	10 " 25
Coal mine cars, loose wheels	20 " 30
Coal mine cars, wheels scraping on sides	60 " 80

We give the foregoing, not because it is entirely correct, but because it fairly represents what engineers ordinarily assume in making estimates for mine haulage and the like.

A hasty survey of the literature on mining shows that engineers usually assume a mine car resistance of 20 lbs. per short ton, which, as we shall show, is altogether lower than is commonly attained in practice.

Resuming the discussion of the resistance to traction as influenced by track conditions, car loads, etc., we may set it down as self-evident that a rail weighing 60 to 90 lbs. per yard laid on ties, spaced 2 ft. c. to c., will bend far less under a wheel load than a rail weighing 16 to 40 lbs. per yard, laid on ties 3 to 5 ft. c. to c. It may also be set down as self-evident that a track having ties well set in ballast is far less yielding than a track with ties more or less carelessly laid without ballast. It is not so self-evident, but it is nevertheless a fact proven by many careful experiments, that to double the load on a given wheel, does not double the resistance to rolling. This is well shown in the experiments of Wellington above quoted, wherein it appears that while it required 5 lbs. to pull each ton of a loaded car, it required 40% more, or 7 lbs., to pull each ton of empty car. We need not go into the theory of this phenomenon here, but carrying the reasoning to its logical conclusion we see that a miner's or contractor's car with its comparatively light wheel load, even if it were placed on well-ballasted track of 90-lb. rails—which it never is—would show a higher resistance per ton than a freight car with its heavy wheel load.

Passing to a consideration of the car itself we have other and perhaps more important reasons why a small car shows a higher rolling resistance. To begin with, the wheels of a mine car are only 16 ins. or so in diameter, on a 2½-in. journal, whereas the freight car wheels are about double, or 32 ins. in diameter, with a 3¾-in. journal.

It is evident that a greater diameter compared with the journal gives a greater leverage in overcoming axle friction, and it is also evident that a greater diameter gives a greater leverage in overcoming slight irregularities on the rail surface. What an important element this journal friction is in small cars will be seen from the results of tests about to be given. Mr. R. Van A. Norris, E. M., Asst. Engr. Susquehanna Coal Co., some years ago made a very exhaustive series of tests (989 tests) on the resistance of coal mine cars. Two styles of car axles were used, one old style, and the other new style, patented by Mr. Jas. H. Bowden. In both styles the wheel was 16 ins. diameter, tread to tread, with axles passing loosely through fixed boxes. The journal of the old style was steel 2⅛ ins. diameter, of the new style 2½ ins. diameter, and 5¼ ins. long. Each car was carefully oiled. The track was a perfectly straight level piece of 42-in. gage, about 200 ft. long, and in rather better condition than the average mine track. The weight of the rails is unfortunately not given. The cars were 41¾-in. gage, 3½-ft. wheel base, 10 ft. long, weight 2,140 to 2,240 lbs. empty, and 7,900 to 9,000 lbs. loaded.

As a summary of the tests we have the following:

	Pounds per ton of 2,000 lbs.
To start one old style car loaded	90
" " " new style car loaded	47
" " " old style car empty	77
" " " new style car empty	49
To pull one old style car loaded at ¼ mile hr.	52
" " " new style car loaded at ¼ mile hr.	32½
" " " old style car empty at ¼ mile hr.	51
" " " new style car empty at ¼ mile hr.	33
To pull one to four old style cars loaded 4½ miles hr.	66
To pull one to four new style cars loaded 4½ miles hr.	38
To pull one to four old style cars empty 4½ miles hr.	56
To pull one to four new style cars empty 4½ miles hr.	30
To pull 20 old style cars loaded 4½ miles hr.	26
To pull 20 old style cars empty 4½ miles hr.	42

One of the most striking features of this summary of tests is that the resistance per ton of a train of 20 loaded cars (old style) is 26 lbs. per ton, as compared with 66 lbs. per ton for a 1 to 4-car train. This brings out a fact that we have never seen mentioned as being of importance in tests of this character, namely, the lower per-ton resistance of a long train of mine cars as compared with a single car. In the ordinary so-called level mine track there are numerous waves forming up and down grades; and in a long train of cars, some are coasting down these waves while others are ascending, so that those going down are pushing those going up hill, consequently reducing the pull on the locomotive draw bar

Another, and perhaps even more important factor may enter to reduce the per-ton resistance of a long train; and that is the action of the forward cars in cleaning the track. Fragments of coal and rock fall upon the track, and these the first few cars must crush; but the jarring of these forward cars may in large measure cause this powdered material to fall off the rails.

Unfortunately, we can find no tests made with cars upon rails of varying cleanliness, but in our issue of March 6, 1902, Prof. Baker has given the results of tests on a clean and dirty steel wagon trackway. On a perfectly clean trackway the resistance was 19 lbs. per ton of wagon and load; on the same track covered with ½-in. of fine dust, the resistance was 28 lbs. per ton; while with ⅛-in. of powdered stone over the track, the resistance rose to 40 lbs. per ton. Mine car tracks, as well as contractor's car tracks, are always more or less covered with powdered rock and earth, and from Prof. Baker's experiments we may safely conclude that this dust forms a very material source of resistance to traction. This being so, we raise this question:

Will it not pay well not only to use care in bedding the ties, and in alining a mine car track, but also to provide a brushing device attached to the front of a mine car to remove powdered material from the rails?

As a result of the foregoing we may say that the engineer who in estimating uses a 20-lb. resistance per ton of mine car load is far below the actual resistance ordinarily encountered, which is 1½ to 2½ times 20, or say 40 lbs., as an average on a fairly level, fairly dirty mine track.

LETTERS TO THE EDITOR.

The Compensation of Engineers.

Sir: Apropos of the compensation of engineers, what do you expect to do, or what can you do, when you have men in the profession who will undertake important work for a song?

Here we have identically the same conditions existing in the water supply department as you appear to have on hand in New York, with this difference, instead of employing engineers at a reasonable figure (which need not have been $12,000 a year, as that city paid), three were found as Consulting Engineers, and it appears, from the daily press, were paid the following munificent sums: One $1,500 per annum, the other two $15 per day when employed.

I beg to enclose a clipping from to-day's "Journal"; it speaks for itself; also a copy of a letter I have this day addressed to the editor.

When men will not value their profession any higher than this, how can you expect the public to do so? This is hardly the compensation of an ordinary public land

surveyor, let alone an engineer who is supposed to be a man of deeper thought and study. It makes one tired, and causes him to feel as if peddling bananas were more elevating, for the peddlers generally try to obtain a fair equivalent, while the engineers will take any crumb thrown them and say "Thank you."

I think a little disapproval on your part of such cheap contracts would be highly beneficial.

Yours truly, J. I. Boggs.

1908 New York Life Building,
Kansas City, Mo., Jan. 5, 1903.

(The enclosures with the letter are as follows. —Ed.)

(From the Kansas City "Journal," Jan. 5.)

When doctors disagree the patient, as a general rule, dies, but when water experts fall out—what then? is the question that is agitating the minds of the officials at the city hall. For be it known that —— ——, of St. Louis, who has but recently been added to the city pay roll at a salary of $1,500 a year and anointed with the title of "consulting engineer," and —— —— and —— ——, both of Kansas City, whose services as experts cost the city $15 every time they blink an eye, are at odds as to the style, make and practicability of high and low pressure pumping engines to be installed in Turkey Creek and Quindaro water pumping stations and —— has checked his baggage for St. Louis to return later.

Editor Journal, Kansas City, Mo.:

Dear Sir: Several items recently appearing in your paper, the latest in this morning's edition, would lead the public at large to imagine that $1,500 per year or $15 per day was an extraordinarily large fee to pay a Consulting Engineer.

My dear sir, you surely know better than this. The city of New York is in identically the same condition over its water supply as Kansas City, and has employed three Consulting Engineers to *study* the question, paying each $12,000 per annum. Their report is to be presented on Nov. 15 next. Now these gentlemen do not abandon their every-day practice and devote their entire time to the city; they simply take this as a "case," identically the same as a lawyer or doctor would, and may treat several "cases" during the interval. For Heaven's sake, stop writing about that little $15 per diem fee; it is hardly any more than is paid an ordinary land surveyor, whereas an engineer must be competent to handle complex questions of mathematics and natural forces.

Fees of from $50 to $100 and over per day are not so unusual in the engineering profession, and I am only surprised that Kansas City has been able to obtain men at the figures mentioned for this very important work. They should receive not less than $50 per day, or $6,000 per year.

I, a stranger in your midst, dislike to take up this subject, or enter into the controversy, but as you seem to be laboring under the impression that $15 per day is a munificent fee for a Consulting Engineer, I could not refrain from correcting your error and endeavoring to point out that it is an exceedingly meager allowance.

Yours truly, Civil Engineer.

The Inefficiency of Joist Hangers of the Stirrup Type.

Sir: The failure of a steel stirrup or joist hanger in a warehouse in Minneapolis on Nov. 7, causing a portion of six heavily-loaded floors to fall, as described at length in Engineering News of Nov. 20, leads me to call attention to a peculiar weakness in all joist hangers of the stirrup type, which I believe is not generally recognized.

Until recently it has probably been the common practice to figure the strength of a stirrup from the sectional area of the metal, but recent tests have shown that a single stirrup never fails by the breaking of the iron or steel, but by the bending of the top, where it lays over the supporting beam, and by the crushing of the wood, or in the case of a wall stirrup by the crushing of the brick.

This will be readily understood if we consider for a moment the effect of the load on the stirrup. The reaction of the end of the header, Fig. 1, is transmitted by the stirrup to the top of the trimmer and is borne almost entirely by the inner edge, A, of the trimmer, and, with the ordinary width of metal used for stirrups, the pressure is distributed over such a small area that the wood is crushed and the moment that the wood commences to crush, a severe bending moment is brought into action, tending to bend up the end of the stirrup, as shown in Fig. 2, which is drawn from a photograph of an actual hanger tested at the Massachusetts Institute of Technology. This hanger pulled over the trimmer at a load of 13,750 lbs. The stirrup was made from ⅝ × 2½-in. wrought iron, hence the stress in each side of the stirrup was only 7,333 lbs. per sq. in., or less than one-sixth of the probable breaking strength of the iron.

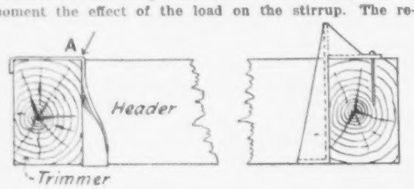


Fig. 1. Illustrating Stresses Carried by Joist Hanger Upon a Wooden Beam.

Fig. 4. Joist Hanger with Top Bracket to Stiffen it Against Bending.

Fig. 3 shows a 6 × 12-in. Van Dorn hanger bent in the same way under a load of 13,300 lbs.

Last April, at St. Louis, Mr. W. A. Tyrell, C. E., made comparative tests on several types of joist hangers for Messrs. Mauran, Russell & Garden, Architects, in which all of the hangers of the stirrup type failed by the bending of the top of the stirrup.

According to the report in Engineering News, the stirrup which gave way in the Minneapolis building failed in the same way under a load of about 15,000 lbs., or only about one-half the safe tensile strength of the steel.

The effect of the load on a wall hanger, when made from a stirrup riveted to a bearing plate, is obviously the same as when used over wood, the only difference being that if the bricks are of good quality they will stand a greater crushing stress than wood, and the ends of the stirrup being firmly held in the brickwork cannot bend as easily. From the above it will be seen that the most serious defect, from the standpoint of strength, in all stirrups is that they do not distribute the load evenly over the top or bearing surface. If a stirrup could be made with a web or bracket on top, as in Fig. 4, the load would be evenly distributed and the metal would have to break before the stirrup could fail.

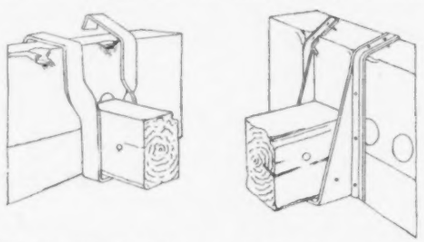


Fig. 2. Showing the Way in Which a Single Stirrup Commonly Fails.

Fig. 3. Patent Stirrup Under a Load of 13,300 Lbs.

The bending of the bottom of the stirrup, between the sides, or the tendency to shear at one of the bent angles, are the next weakest points in the ordinary stirrup, although a well-designed stirrup will not break in either way unless the beam supported is very wide, say over 12 ins.

A double stirrup is stronger than a single one because the stirrup cannot pull off from the trimmer or header, but must break at some point before the beams which it carries can fall. Fig. 5 shows the condition of a double stirrup made from ⅝ × 2½-in. wrought iron, carrying two 8 × 12-in. beams over one 12 × 14-in. beam, after it had failed under a load of 28,825 lbs. on each side. In this case the stress in the iron was 15,372 lbs. per sq. in. and the iron broke in the lower corner.

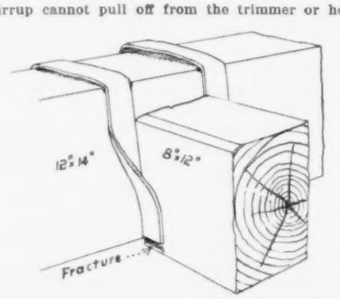


Fig. 5. Showing the Effect of Two Loads of 28,825 Lbs. Each on a Double Stirrup, Made from ⅝-In. × 2½-in. Wrought Iron.

The only joist hanger that the writer has seen which has suitable provision for resisting the bending moment on the top shelf or support is the Duplex hanger, which has a nipple at the top for inserting into a hole bored in the side of the girder or trimmer. The diameter of these nipples varies from 1½ ins. in the smallest size to 2⅞ ins. in the largest size, thus affording sufficient depth to ensure a practically even distribution of the stress over the bearing area. The resistance of these nipples and the slight crushing of the wood under them, as shown by carefully conducted tests, is very remarkable. In the tests made at the Massachusetts Institute of Technology a No. 75 (two-part) hanger with nipples 2⅞ ins. in diameter and 3½ ins. long broke under a load of 39,550 lbs. This is equivalent to a bearing under the lower half of the nipple of 1,977 lbs. per sq. in., and yet the compression of the wood and the effect on the girder was very slight. The hanger failed by the breaking of the iron directly under one of the nipples. In the St. Louis test, conducted by Mr. Tyrell, a hanger of the same size carried 38,000 lbs. without apparent injury to the hanger and without serious injury to the girder.

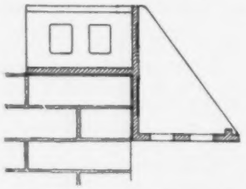


Fig. 6. Section Through Heavy Duplex Wall Hanger.

The Duplex wall hangers are formed on the principle illustrated by Fig. 4, so that they ensure almost, if not quite perfect distribution of the weight over the masonry. Fig. 6 shows a section through one of the heavier patterns of Duplex wall hangers. The strength of these hangers is probably measured by their resistance to shearing.

F. E. Kidder,
Architect and Structural Engineer.
628 14th St., Denver, Colo., Dec. 30, 1902.

Ration Lists for U. S. Geological Survey Parties.

Sir: Apropos of your article, "A Prospector's Grub Stake," in your issue of Dec. 11, it may interest your readers to know something of the ration provided for field parties of the United States Geological Survey.

This ration is the outcome of 35 years of experience of large numbers of parties working each year in all portions of the United States and Alaska. It has necessarily undergone several changes. The accompanying list was that adopted in 1882 from the U. S. Army ration, modified by the experience of the old Hayden, Powell and King surveys in the far West. It was used by the writer and his assistants for nearly 15 years and was found admirably suited to the conditions for which it was prepared. These especially required that it should be light and compact as possible, as in the early days all provisions and camp outfit were transported on pack mules. The same ration, slightly modified by substitution of lighter or less bulky articles, is still found admirably suited to the arduous work encountered by parties which have been making reconnoissance surveys during the past five years in Alaska, where all provisions had to be transported in boats or on the backs of men.

In 1893 this ration list was carefully revised by a committee of experienced men and the following is the result, which will be found to be but slightly changed from the 1882 list, chiefly in the direction of rendering the ration more liberal and therefore more bulky, because the changed conditions permit of the easy transportation of outfit in wagons, and usually over relatively short hauls as compared with those of the earlier exploratory days.

This last ration list has been in use for about ten years, and a committee which carefully reconsidered it a few weeks ago found that no changes were necessary. It is ample for all the uses of surveying parties and yet neither extravagant nor bulky. The old ration weighed 5.13 lbs. per day's ration for one man. The new ration weighs 5.29 lbs. per day for one man, yet from it the most satisfactory and elaborate meals can be prepared by making the substitutions permitted in the footnote.

A careful investigation of the cost of these rations made at the time of the change in 1893 developed the fact that the cost of the old ration averaged over a period of years, as taken from vouchers inspected, varied in different portions of the country from about 36 cts. in the Southern States to an extreme of about 75 cts. in the far northwestern States, with an average of about 45 cts. Since that time, owing to increased facilities of transportation, the value of this ration has diminished until it probably ranges now between 35 cts. and 55 cts., the average remaining about 45 cts.

It will be observed that the above ration is more liberal and more costly than that quoted in your article. It is not a prospector's ration, but one well suited to an engineering or surveying party, the difference being that in the latter case one member of the party is always employed as cook with no other duties to perform, and it is therefore possible to utilize a greater variety of provisions. In the case of the prospector's outfit, it is customary for one of the members of the party to perform the duties of cook in addition to the labors of camp hand and prospecting. Under such circumstances the least amount of cooking that can be done the better and the least variety of food to be prepared the easier. Hence the crude hand-to-mouth style of living is employed, which soon becomes irksome and would entirely pall upon men who are working in employment, as compared with those who are hustling for their prospective fortunes.

If you care to continue this matter further I would suggest reference to my book on "Topographic Surveying," published by Wiley & Sons, New York. In a chapter on "Camping" you will find extended notes on the cooking utensils and camp equipment recommended on the basis of an extended experience for various conditions of field work. Very respectfully,

H. M. Wilson.
Geographer U. S. G. S., Washington, D. C., Jan. 9, 1903.

(The extract from the Government official pub-

lication enclosed with the above letter is as follows:—Ed.)

GEOLOGICAL SURVEY RATION.

A ration is the food estimated to be necessary to sustain one man one day. To facilitate the field work of the Geological Survey, its parties in camp may puchase at the expense of the Survey the rations described below. The amounts of the various articles in the ration are designed to be sufficiently liberal for all circumstances. They are maximum amounts, which must not be exceeded. This ration allowance is neither an emolument nor a perquisite, but is a provision for facilitating the field work of camping parties.

The Survey ration is made up of the following articles and amounts:

Article.	For 1893. 100 rations.	For 1882. 100 rations.
Fresh meat, including fish and poultry (a), lbs.	100	100
Cured meat, canned meat, or cheese (b), lbs.	50	45
Lard, lbs.	15	5
Flour, bread, or crackers, lbs.	80	80
Corn meal, cereals, macaroni, sago or cornstarch, lbs.	15	15
Baking powder or yeast cakes, lbs.	5	5
Sugar, lbs.	40	40
Molasses, gallons	1	..
Coffee, lbs.	12	12
Tea, chocolate, or cocoa, lbs.	2	1
Milk, condensed (c), cans	10	4
Butter, lbs.	10	..
Dried fruit (d), lbs.	20	20
Rice or beans, lbs.	20	20
Potatoes or other fresh vegetables (e), lbs	100	50
Canned vegetables or fruit, cans.	30	..
Spices, oz.	4	4
Flavoring extracts, oz.	4	2
Pepper or mustard, oz.	8	4
Pickles, qts.	3	3
Vinegar, qts.	1	1
Salt, lbs.	4	4

(a) Eggs may be substituted for fresh meat in the ratio of 8 eggs for 1 lb. of meat.
(b) Fresh meat and cured meat may be interchanged on the basis of 5 lbs. of fresh for 2 lbs. of cured.
(c) Fresh milk may be substituted for condensed milk in the ratio of 3 qts. of fresh for 1 can of condensed.
(d) Fresh fruit may be substituted for dried fruit in the ratio of 5 lbs. of fresh for 1 lb. of dried.
(e) Dried vegetables may be substituted for fresh vegetables in the ratio of 3 lbs. of fresh for 1 lb. of dried.

An Answer to Some Anti-Metric Arguments.

Sir: I have followed with considerable interest the discussion on the bill for the legal adoption of the metric system, now before Congress. While being neutral myself, not thinking that the passing or rejection of the bill will make or break the nation, nevertheless some of the arguments in the anti-metric papers, given in the supreme spirit of ignorance, have aroused my antagonism. Such articles, for example, as the bombastic letter by Mr. C. T. Porter, published in the Dec. 25 issue of Engineering News, will do more toward hastening the adoption of the measure than any amount of favorable argument. In this article he starts by giving an historical sketch of the first adoption of the metric standard by France. In this he departs from the main issue, for, while the relation of the length of the meter to the length of the quadrant of the earth's surface was the original reason for the adoption of that particular length as a standard, in the vain hope that it might simplify certain terrestrial and astronomical calculations, the fallacy of this idea was soon discovered, and it was seen that any other length would have done as well for a standard. The idea, as revised, was simply to have a practical decimal system which would be applicable and uniform for all measures and all weights. The metric system, as now in use by all Latin countries and some of the Teutonic, seems to me to fill these conditions. The method of continuous bisection is of very little advantage to the computer when compared with the decimal system.

"Secondly," to quote from the above-mentioned letter, "the metric system is absurd, in confounding together weights and measures, things which are entirely dissimilar and unrelated." The chemist and the assayer can tell a different story about this absurdity, and can show a great simplification in their operation from the fact that a c.c. (cubic centimeter, a unit of liquid measure) of water, at its maximum density, weighs 1 gram. Also the hydraulic engineer.

"In the English system of linear measurement we have uniformity," says the writer, and more to the same effect. Let us see. The government surveyor measures land with a chain 66 ft. long, divided into 100 links of 7.92 ins. each. He does this to simplify his computation of the area in our excellent system of 43,560 sq. ft. to the acre and 640 acres to the square mile. Then comes the railroad surveyor with his 100-ft. chain, each foot divided to 10ths and 100ths. He lays off the curves, makes topographical surveys of the bridge and station sites, and sets the mile posts, 52 stations plus 80 ft. apart! Then come the bridge and building plans, dimensioned in feet, inches and vulgar fractions, which cause the constructing engineer to reduce the measurements on his topographical plan to a like standard. Lastly, the division engineer, in calculating his cubic contents of excavations and embankments, has to reduce them to cubic yards by division by that very convenient number, 27. This is our "very ideal of uniformity." In our standards of weight and measure the lack of uniformity is still more apparent. We have the U. S. gallon, the British imperial gallon, and the wine gallon. We have the avoirdupois weight, the troy weight, and the apothecary's weight. Drugs are bought by avoirdupois weight, but mixed by apothecary's weight. The values in ore are calculated in the troy system for the precious metals and in the avoirdupois for the base metals.

I do not contend that the metric system has any advantages over any other decimal system that we might adopt, but if we do any changing at all, why not use a standard which is already widely used, and thus, instead of adding a new system to an already too great variety of them, and which would only be used in our own country, assist in spreading a uniformity of weights and measures over the whole world?

W. C. Hammatt, Assoc. M. Am. Soc. C. E.
Santa Barbara, Chihuahua, Mexico, Jan. 1, 1903.

From a Metric Advocate.

Sir: I understand that there is still a controversy as to the advisability of adopting the metric system. It is certainly hard to explain to blind men what light is. So it is with those who never used the metric system; they cannot realize its simplicity.

You may tell them that it is a hundred times easier to learn, a hundred times easier to use, that it removes 99% of the chances of errors, that even the present standards of machinery can be represented easily, that many nations (whose mechanics were not smarter than Americans) have adopted it without inconvenience, and not a single one would now be willing to return to the old way. To all that they reply: "I don't like it."

This is like the man who does not like oysters. He never tasted them because he does not like them, and cannot be induced to taste them because he knows he does not like them.

There is as much difference in the use of the present chaotic system of weights and measures and the metric system as there is between a flail and a threshing machine, yet 50 years ago I have heard in a country town a debate on flail vs. threshing machine, and the flail came out victorious. Fortunately the threshing machine did not need the assistance of Congress as the metric system does, and it seems to me that Congress has an easy way to determine whether those who favor it or those who object to it are right. I would find out on which side are those who by their education and experience have been led to thoroughly know and thoroughly use the metric system. As they are all in favor of its adoption I would judge that, knowing both sides of the question, they ought to know what they are talking about, while those who object to it never have used it. Consequently they simply do not know.

Arthur Lagron, C. E.

Peoria, Ill., Jan. 7, 1903.

(Unfortunately for our correspondent's argument, many men who have used the metric system and are thoroughly familiar with it are included among those who oppose legislation to compel its use. An example is the letter below, received by us just after Mr. Lagron's.—Ed.)

Experience with the Metric System in Mexico.

Sir: In your issue of Dec. 25 "C. S." would lead those who have never had any experience in the matter to believe that the metric system never "gives any trouble" in European and South American countries, and cites his "many years of practice there" as proof.

It has occurred to me that if the experience of American engineers in these countries could be expressed through the medium of your valuable paper it would be very interesting and would enable your readers to form their own opinions upon the subject.

I hardly think the metricists would agree to this proposition, however, for, judging from my own experience of almost six years in Mexico, the testimony of the majority would be against it.

The work on the first Government wharf and Custom House at Tampico, of which I had charge, was done under United States measurements because all of the manufactured material came either from the United States or from England. At El Higo, State of San Luis Potosi, where I was the engineer for the American interests in the French sugar factory, the boilers, grinding machinery, electric plant and filter system were all installed under United States measurements, because manufactured in the United States, while the balance of the work, being French was done under the metric system.

I wanted to speak more particularly, however, of the metric system as applied to railroad work. On surveys in Mexico, angles are still measured by degrees and its subdivisions. It cannot be said that measurements of angles are less important than measurements of distances in engineering work, or that there is any greater liability to error in using degrees and subdivisions thereof, than in any form of the metric system that might be grafted upon the functions of the circle. The degree, like the foot, is "tied irrevocably to the past" and stands as a very strong argument against the metric system, because it is still in use in this metric country.

The foundation of the railroad survey is the station. In the United States it is 100 ft. In Mexico it is 20 meters. What is there about 20 meters that suggests, even remotely, the idea of a decimal? Yet the whole basis of the claims for metric system is the decimal, and the use of the decimal only.

Twenty meters is almost too short a distance to be of the most economical service; 10 meters is impossible. In 10 meters the decimal idea would obtain, so it would in 100 meters. But 10 meters is too short and 100 meters is too long. Both are impracticable for that reason. The result of the experience of the engineers in Mexico is that 20 meters is adopted as the station, and we have the very convenient form of distance expressed in the beautiful metric system thus: "Estacion, 2,575 + 17.25 m.," or, in other words 51,517.25 m. By inspection it is easy to see that there are two bases of enumeration. In the first the unit is 20 meters. In the second part of the quantity, the unit is 1 meter, and then we have the farce of adding 2,575 units of 20 meters each to 17.25 units of 1 meter each, in the metric system. Computing in pounds, shillings and pence is not more absurd, especially as the metric system is recommended for the elimination of all our "compound" troubles.

In taking intermediate readings on surveys, and in cross-sectioning and staking out earthwork on construction, the decimeter is too large a subdivision to use with accuracy. To approximate as close a reading as is taken under the American system the rod would have to be read to the quarter of a decimeter, as, for instance, .325 m., .35 m., .375 m., thereby increasing the decimal spaces. In practice the readings are taken to the half decimeter, still necessitating the use of two decimal places, and thus increasing the work both in the field and in the office, with a corresponding increase in the liability to error and without increasing the accuracy of the work.

In all the work connected with the grade line, constant care must be taken to observe and remember that the per cent. of grade is not expressed in terms of the number of stations, but of half of them. Thus 1% of 10 stations is not 1 meter, but 2 meters.

If the civil engineer should follow the example of the metricist and adopt a "makeshift of a decimal system" as they have done, by using the centimeter or millimeter for a unit, instead of the meter, and adopt some subdivision of the meter for their unit, we would have confusion worse confounded in railroad work. Civil engineers' time should be, and is, too valuable to stop and interpolate into their notes and reports such expressions as, "These quantities are expressed in decimeters," "These distances are in meters," etc., as is done in treatises where the metric system is used.

In our American system, on the contrary, where 100 ft. is the station, and the foot is the unit, subdivided decimally we have a system as perfect as could be desired. The unit is not so cumbersome that engineers have to resort to subdivisions of it in order to express themselves with a limited use of time, note book or printer's ink.

One place in the decimal of the foot is as close a reading of the rod, either on a survey for immediate readings or on construction, as either party to a contract will ask for. I would advise "C. S." that this is "no makeshift of a decimal system," but one that is almost universally used among Americans and Englishmen and is the foundation of railroad construction which in this country, with almost 200,000 miles of railroad, ought to be something of a recommendation.

It is true we have the cubic yard yet, but that is composed of cu. ft., and to remove this last irritating feature from the argument a cubic unit of 10 or 100 cu. ft. might be adopted, thus eliminating the one inconsistency of the American railroad system of measuration, and making it a still more perfect decimal system than the metric. Its adoption would not disturb those other "measures of length" that are "irrevocably tied to the past," but rather would fix and establish them more firmly for the future.

Very respectfully, A. S. Robinson.

St. Ignace, Mich., Jan. 8, 1903.

Concerning Systems of Measurement.

Sir: Anent the discussion of the metric system the writer would like to call attention to some things in his own experience within the past two months.

Being a Western engineer in general practice considerable architectural work comes into the office along with land surveys and "such like." One day a farm survey had to be made, and for convenience in calculations the steel tape used was the 66-ft. tape divided into 100 links. This gave chains and decimals of chains, but the farmer insisted upon the result being given him in rods and yards because "Measures of length are tied irrevocably to the past.' Gunter's chain has been in use a long time; but the rod and yard for common people antedate it. The metric system is likely to be adopted before the ordinary people commence to think in chains and links. The

farmer says, "A little over one pace is a yard and about six paces make a rod."

In the afternoon of the same day a survey of a mining ditch was completed. It was run out with an engineer's tape decimally divided and the leveling rod was 15 ft. long with decimally divided feet. The result on cuts was given in sixteenths of an inch to the rod and for flumes in sixteenths of an inch to 12 ft., as 12 ft. was the length of boards used for boxes. The graders had the rod as a unit of lineal measurement and the carpenters did their thinking in box lengths.

The next day the maps were made and the scale was in inches, decimally divided, while the details of flume and trestle were in inches divided in the ordinary way by continual bisection. To make the thing worse, the president of the mining company asked that all distances and dimensions be also expressed in the metric system. He believes the metric system will be adopted before construction commences. The writer shares this belief, though from different reasons!

The above work being out of the way, work was resumed on some house plans with the scale expressed in the bisected inch. The lot for the building was staked out with the hundred-foot tape with decimally divided feet. The building was set out on the lot with a tape having the feet divided into twelfths, and each twelfth into eighths. The grade was expressed in the grade book in decimals of a foot, but the carpenter had to have it in eighths of an inch.

The above facts and almost daily similar ones may be noted. Yet there is absolutely no confusion. To the writer it seems perfectly logical to have several different systems of measures of length, and the metric system will never displace all others. The division of the foot into inches is not so logical as the division of the inch into halves, quarters and eighths. The former is arbitrary and the latter natural, yet centuries of use have made both easy to use. The duodecimal system of measurement in its completeness gave us the twelfth divided foot, in which the half is six parts and the quarter is three parts of the whole, but the continually bisected twelfth could not be supplanted by a twelfth divided into twelves.

School books make a distinction between common fractions and decimal fractions. Many teachers say it is necessary to make the distinction. By folding strips of paper a child can by continual bisection understand common fractions. It must first be taught to measure before understanding decimal fractions. Our financial system is no criterion. Fifty cents is half a dollar. Twenty-five cents is a "quarter" or "two bits." Seventy-five cents is "six bits."

To the electrical engineer and physicist, who occupy a field wherein the common people have little share (except as sharers of ultimate benefits) the metric system is (or is claimed to be) peculiarly adapted.

To the mechanical engineer, who makes articles in every-day use by common people, the foot divided into inches and the inch divided into eighths seems admirably adapted. For his own convenience in calculating he can use decimals and give results in units the people can understand. If he is making articles for export he can use the systems in use in the countries to which the article is to go.

The architect finds it easiest to use the bisected inch, as all his work is done with men who habitually use it.

The civil engineer—but here we must pause. For his especial benefit land measures will not be disturbed. He can still use for areas the Gunter decimal chain, than which nothing can be more convenient. The rod will be with him, and the yard, and also the foot. He will, in addition, have the metric system. Where is the benefit to the civil engineer if he preserves ancient systems of measure for part of his work and must continually be converting scales for other parts of his work? We should go thoroughly into the matter or not at all. Either give us the metric system for everything or let us retain what we have. For short measure without long calculations the foot and inch are in such common use that there is no difficulty in using them. For the massive works of the civil engineer the decimally divided foot is found to be very convenient. Let us keep these standards.

The only trouble with our present standards lies with the man on the border line. In scientific circles it is the engineer who has to interpret to the common people (and they are many) the conclusions of the scientists (the few) which come to him expressed in the convenient (scientifically) decimal metric system and which the people must have in the convenient (to them) system of their fathers. In business circles it is the salesman who places domestic goods abroad. In the case of the salesman the trouble can be remedied by his house having a set of standards for domestic business and a set for foreign business. In the case of the engineer he should be thankful that his lot is no worse. Under the present arrangement only a few are troubled. Under the new arrangement every one of us will be engaged in educational work until death relieves us. And the people will all be mightily troubled.

MacFarlane in "The French Revolution," speaking of the extraordinary calendar adopted by the French in 1793, says:

. . . . . instead of our twenty-four hours to the day and sixty minutes to the hour, the day was divided into ten parts, and the tenth was to be subdivided by tens and again by tens to the minutest subdivision of time. New dials were ordered to mark the time in this new way, but before they were finished it was found the people were puzzled and perplexed . . . . and the hours, minutes and seconds were left as they were.

"Measures of length are irrevocably tied to the past." The vara is a legal measurement in California, and the name will never disappear from the records even if work is actually done in other units. Men talk glibly of the vara, but would be puzzled to explain it. Pace off 50 varas and you will find the length to be 137½ ft., and that the vara is in fact practically one pace. So our ancient systems of measurement had the yard, which was three times the length of the foot, and the inch, which was the length of three barleycorns. Men noticed with superstitious awe that the number of barleycorns in one foot equalled the number of inches in the yard, and an apparently accidental matter became one of holy import. And when the pace of a lusty man was found to be practically a yard, nothing more was needed until Piazza Smith got to work on the pyramids.

The length of the yard (under whatever name) and of the foot varied, of course, with the stature of the people of any country. But as the Anglo-Saxon made his influence felt over the world the standards were his where his goods were used. In the back districts, where his influence was not felt, old standards prevailed and their names are still preserved.

The Anglo-Saxon has several systems of measurement, each most convenient for its purpose. Is he to give them up and be put to mighty inconvenience for a century to satisfy visionary enthusiasts? What benefit will there be?

The writer believes if the change is to come it will come with time without legislation other than statutes defining equivalents. The Western States have statutes defining a miner's inch in cubic feet per second. The miners all use the inch as being more easily understood, and where water is plentiful it is all right. When water is scientifically measured the miner recognizes the province of the engineer and steps aside. In conversation, however, he talks of the inch. It only came into use two generations ago and the second-foot trod on its heels, but it will take several generations to get rid of it.

The mechanical engineers cannot be accused of "old fogyism" simply because they do not favor a present change by legislation. The term "old fogy" cannot be applied to men who fearlessly destroy thousands of dollars' worth of machinery in a year to replace it with something better. When these men see a money value in the wholesale adoption of the metric or any other decimal system of measurement it will be done. Of this we may be sure.

Ernest McCullough.

Lewiston, Idaho, Dec. 31, 1902.

Notes and Queries.

F. H. W., Winona, Minn., writes:

Will you please inform me whether or not the custom of making tests of cements by heavy purchasers is growing more or less prevalent? In other words, are the various brands becoming well enough established so that elaborate testing is not considered as necessary as formerly?

Our impression is that the exact contrary is the case, and that systematic testing of cement by large users is more common now than ever before. It is true, of course, that cement makers regularly test their product, and no reputable concern intends to furnish unsound cement. On the other hand, the user's test for fineness enables him to know what proportion of the cement which he is receiving is really cement and what part is unground clinker, of little more value than sand for cementing qualities and likely to make the cement unsound.

W. M. F. has to rebuild some street railway track in brick paving to accommodate railway freight cars as well as street cars, and wishes to know what section of rail would be best under the circumstances. The only section he can find which will accommodate both kinds of wheels is the Pennsylvania Steel Co.'s No. 217, which is a 7-in. tram girder rail. Mr. Wilgus, Chief Engineer of the New York Central R. R., was at one time interested in the design of a 9-in. 157-lb. girder rail for this purpose, but this rail is not on the market.

We do not suppose that many grooved girder rails are made with groove large enough for the flanges of ordinary car wheels. If a T-rail can be used, the special brick forming the groove might be set far enough away to widen the groove by placing book tile against the web of the rail. Or the brick might be chipped to give the necessary width and depth of groove, and the rough surface of the groove then smoothed off with cement grout or asphalt. Perhaps some of our readers who have built or operated street tracks carrying steam railway cars can give some information on this point.

In the article describing the 64th St. sewer tunnel and outlet sewer work at Brooklyn, N. Y., in our issue of Jan. 1, 1903, we failed to say that all the brickwork was laid in natural cement mortar and that considerable natural cement concrete was also used.

L. N., Louisville Ky., asks where he can obtain a formula for or method of finding the tractive power of a three-cylinder compound locomotive.

As tractive power of locomotives is commonly computed, from the weight on the driving wheels, it will make no difference what cylinder construction is used. If, however, it is desired to compute the tractive force developed by the cylinders, it can be done by the same method for compound locomotives as for the simple locomotive. The rule given in Forney's "Catechism of the Locomotive," p. 372, is:

The tractive power of a locomotive is equal to the product of the total area of the pistons by the average effective steam pressure in lbs. per sq. in. on the piston during the whole stroke, and twice the length of the stroke of the piston; this product to be divided by the circumference of the driving wheels.

In the case of a compound locomotive, of course, the area of each piston is multiplied by the mean effective pressure upon it, and the sum of the work done by the several pistons is found. It will be seen that the above method is simply to find the foot pounds of work done in the cylinders during one revolution of the driving wheels and then to divide this power developed by the distance through which the train is moved. In this calculation no account is taken of the friction of the locomotive itself or of the power required to move the locomotive and tender. To find the drawbar pull exerted on the train behind the tender these quantities must be deducted.

GOVERNOR ODELL ON THE PROPOSED 1,000 TON BARGE CANAL.

The following is the portion of Gov. Odell's message to the legislature which deals with the project for the construction of a 1,000-ton barge canal, from Lake Erie to the Hudson:

The desire to maintain the commerce at the ports of New York and Buffalo, and the failure of canal transportation to adequately meet the demands of trade, have led those who have given consideration to this subject to suggest a very material increase or enlargement of canal facilities.

There is perhaps no subject which you will be called upon to consider that is fraught with so many difficulties, and the failure of every attempt in recent years to make canal traffic more effective should be a warning, and should preclude hasty conclusions as to the proper remedy to be applied.

That the Erie Canal has performed an important work in the development of our State is not questioned. That it is the desire of all of the people that it should remain as a factor in the adjustment of freight rates is equally true. But as to the extent to which the State should go in the direction of improvement there is a wide divergence of opinion.

There has been, unfortunately, no policy in this matter which had the character of permanence. Neither the lowering nor the abolition of tolls upon the canals brought, as was hoped, an increase of traffic. On the contrary, there has been a gradual but certain decrease, both in tonnage and in the number of boats engaged in canal traffic.

Under the present system, disregarding for the time being the factor of cost which the State in the nature of a subsidy grants, the fact is apparent although the per ton mile cost of canal transportation is but 0.19 ct., while upon the railroads 0.59 ct., that the railroads are increasing their traffic while the canal is gradually losing it.

Why shippers are willing to pay this increased cost becomes therefore a proper subject for inquiry. Is it because of greater facilities and more prompt shipment at other outports that this decline in canal traffic is due? And will an enlarged canal win back the commerce which we have lost?

It can be taken to be a certain and fixed conclusion that commerce will follow the line of least resistance, where the cost is lowest and where facilities for reloading freight for export are best. The inability to use the canal for at least five months of the year to my mind is first of all a serious consideration in competition with railroad transportation, which, in addition to the terminal charges at New York and breaking of bulk at Buffalo, seem to give to the railroads an advantage which should be thoroughly considered before an enlargement of the canal is authorized.

Still lower freights seem to be the remedy which it is hoped may restore this inland commerce. This can be accomplished in one of two ways—either by greater speed upon the canal, or increased carrying capacity of the boats. If it is possible to accomplish the desired results through either of the methods suggested, I am convinced that by reason of the decreased cost we can exact a toll which, while in no way interfering with the use of the canal, would assist in its maintenance and in the payment for the improvement.

I have endeavored to give to this subject the consideration which its importance demands, and have heretofore expressed myself and now reaffirm my belief in the thousand-ton barge plan.

I cannot urge too strongly upon the legislature the necessity for immediate attention to this important problem, and while recommending that every consideration

shall be given to the various interests involved, we should recollect that above every other claim the prosperity and upbuilding of our State are foremost. While giving all weight to the expense involved, we should not be deterred from any expenditure that will hold the supremacy of which we are all justly proud.

I hope that the conclusion reached may be so supported by data and figures that there shall be no dissent from the deductions which are thus arrived at, and that the people may be put in possession of every detail that is necessary to enable them to speedily pass upon and express their approval or disapproval of the plans to be submitted.

In my last message I advocated the deepening of the canals to a 9-ft. level, with locks capable and large enough to provide for 1,000-ton barge tonnage. To this subsequently suggestions were added that both the Oswego and the Champlain Canals should be equally enlarged.

This proposed measure failed of passage, I am convinced, because of an honest belief upon the part of many members of the legislature that the plan proposed was inadequate to meet the requirements of commerce. At the time of the submission of the nine-million-dollar plan it was generally conceded by those interested in canal traffic that a 9-ft. canal would be adequate to meet all demands.

The failure of that sum to complete the improvements led to the appointment of a commission by my predecessor, which commission submitted a plan for the 1,000-ton barge canal, and to that project the commercial bodies of New York and Buffalo stand committed in the belief that no other remedy will produce the desired results, while the interior cities and others who are affected are as earnest in their opposition to the larger plan and are as firmly convinced that a canal completed along the plan of the 9-ft. level will be sufficient for all requirements.

Therefore the friends of the canal, while united in the greater cities, are at odds in other sections of the State over the amount of expenditure which the commonwealth should authorize for the completion of this important work.

So far as the 1,000-ton barge canal is concerned, I had thought that the route known as the Oswego, Ontario and Olcott at a much less cost would be sufficient for all purposes and would secure the result desired much more speedily than the so-called interior route. Those who have given the Lake Ontario, Oswego and Olcott plan study are firmly convinced, however, that it is impracticable, and that at the time when the canal traffic would be at its heaviest it would be impossible because of adverse winds and dangers of navigation.

So we are forced to the conclusion that the only practical route for canal traffic for a 1,000-ton barge would be along the more expensive line, which can only be built at a cost under the State Engineer's estimate, and assuming that the bonds were for 50 years and the interest at 3%, of $193,980,967.50, principal and interest.

This plan only contemplates the deepening of the Champlain Canal to 7 ft., but the advocates of canal improvement now desire that it should also be deepened to a 12-ft. level, which would increase the cost to $215,000,000.

It is well known that no great undertaking of this character ever was completed within the engineer's estimate, but owing to increase in the cost of labor and material, there should be a factor for safety of at least 20% more, which would make a probable ultimate cost for construction of over $255,000,000 in principal and interest, from which should be deducted the interest of the sinking fund.

Suggestions have been made, and it is only fair that they should be presented to you, that if the canal were enlarged to a 9-ft. level and by the use of the water powers of the State and by the introduction of electric motors that not only the same object could be accomplished, but that sufficient revenue could be derived from the sale of power to almost maintain the canal.

The cost of the electric equipment and providing water power would be much less than under the 1,000-ton plan, and perhaps would accomplish the same results.

If this be feasible, I am sure that all who are interested in the welfare of the canals would be glad to give it consideration. If this plan should be adopted, the canal could be constructed within two or three years and the constant withdrawal of commerce could be checked much more rapidly than under the 1,000-ton barge plan, and it could be provided for under the present Constitution. The former would require an amendment.

If it should be deemed wise to select the 1,000-ton barge plan, it could be submitted to the people this fall under the 18-year bonding clause of the Constitution, and no work performed until the adoption of a Constitutional amendment extending the time of payment. In the event of a refusal by the people to so amend Section 4 of Article VII. under the same section the legislature can repeal or render inoperative the expenditures authorized, and thus safeguard against excessive taxation, which would be required for the improvement.

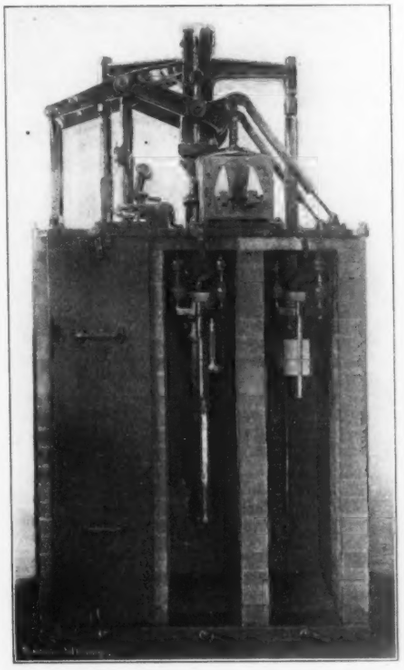
In the event of the 1,000-ton barge plan being authorized, I would recommend the adoption of a concurrent resolution providing for the reimposition of limited tolls, which would perhaps produce revenue enough to provide for the maintenance of the canal, believing that the lowering of the freight rates would be so great that a tollage could be easily met without interfering with the results which it is hoped to accomplish under this plan.

The money for payment of principal and interest of the debt could be met by a dividend tax upon the capital stock of manufacturing corporations, which would produce about $2,400,000, and by modifications of existing revenue laws by slightly increasing the rates affecting others than corporations. But as it is not necessary to provide this revenue until the plan shall be approved by the people, there is no immediate necessity for the consideration of this part of the problem other than the adoption of a resolution for the reimposition of tolls, which must be by Constitutional enactment.

A NEW AUTOMATIC OIL-SWITCH FOR HIGH-TENSION CIRCUITS.

Perhaps as interesting a feature as any other in the modern history of electrical control apparatus is the development of the high-service switch. The demands placed upon this device are severe, its purpose being to pass or interrupt currents of heavy volume at high tension; moreover, it must primarily be the most reliable element of the entire circuit or system.

For the heaviest service the open air break form of switch has been found quite inadequate, and it is rendered additionally objectionable by being a danger to persons and often a serious fire hazard. In its place there has come into use a type of switch in which the circuit is broken under oil and in an enclosed fireproof chamber, the working parts of the switch being located outside of this chamber. This form of switch is particularly convenient where it is desirable or necessary to operate the switches by auxiliary control instead of by hand. It is possible then to place all the switches in a room by themselves, and, by operating them electrically through low-voltage auxiliary circuits and relay switches, to keep the switchboard entirely free from high-tension circuits.



Eight-Cylinder Oil Pump for Steam-Engine Lubrication.

This arrangement has been adopted in all the recent very large electric generating stations, and also in a goodly number of medium-sized stations. It makes possible a remarkably compact arrangement of the controlling instruments and relay switches, and places the largest station under as ready and simple control as the very much smaller stations of former years. The automatic oil-switch is of course the most interesting part of such a modern switching system. One of the most recent forms of oil-switch is shown in the accompanying view; it is a three-pole double-break switch which has just been brought out by the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., under the name "Type C Circuit-Breaker." The following is a short description of this switch.

This switch is intended for three-phase alternating circuits. The supporting and enclosing structure of the apparatus is a brick chamber divided by two vertical brick partitions into three compartments. Each compartment is intended for the terminals of one pole, and contains an oil-tank in which the two breaks of that pole are made. The three compartments are covered over by a soapstone slab on which the operating mechanism of the switch is mounted.

In each of the three compartments there is near the top a horizontal cast-iron frame, suspended from the soapstone cover slab by strain insulators. The oil tank is hung from this frame, but it is arranged to slide vertically on guides so that it can be lowered for filling, etc. The frame also holds two porcelain insulators, through which the two terminals of that pole pass downward and connect each to a vertical copper rod projecting into the oil. A U-shaped piece of copper is arranged so that it can connect the lower end of these rods and thus close the circuit of that pole. It is held on a wooden rod which passes up through the cast-iron frame and through the soapstone cover; at its upper end this wooden rod is attached to an operating crosshead by which it may be moved downward to open the circuit. When the rod with the attached copper U-piece has been pushed down, and has thus opened the circuit by a double break, the wooden rod stands between the two copper terminal rods and thus guards against the current jumping across.

The operating mechanism for the switch comprises a crosshead connecting the tops of the three wooden rods, a system of links giving a straight-line vertical motion to this crosshead, and devices for raising and lowering the crosshead, i. e., for closing and opening the switch. The switch is closed by a set of electro-magnets energized by the low-voltage control circuit, which magnets act to raise the crosshead. A pair of toggle links is provided to hold the crosshead in the closed position; the toggle may be released by a blow from the armature of a tripping magnet. This magnet is energized by the low-voltage controlling circuit.

The automatic or overload circuit breaking mechanism is a small relay switch, fed by series transformers in the main circuits, and actuating a control switch mounted on the main switchboard. This control switch is also arranged for manual operation and serves to either open or close the oil switch by means of the magnets described. It is of the drum type, and has three positions, viz., "Closed," "Off" and "Open." When the oil switch is to be closed, the control switch is turned by hand to "Closed," and thereby connects the low-voltage current so as to operate the closing magnet of the oil switch. As soon as the hand is removed from the control switch, however, it springs back to "Off," in which position the overload relay is connected to trip the control switch under the proper overload conditions. When the switch is automatically opened under such conditions, an electric lamp on the switchboard is lighted so as to attract the operator's attention. If, however, the control switch is thrown to "Open" by hand, thus opening the oil switch, this lamp does not light.

In order to give a check on the proper response of the oil switch to the operation of the control switch, a small indicator is mounted on the switchboard; it consists of an electro-magnet with a pivoted armature capable of turning through an arc of about 90°; the armature moves a pointer over a disk to show the open or closed position of the oil switch. The indicator is actuated by a small knife-switch connected with the operating links of the oil switch.

The overload relay, which serves to trip the control switch when an excessive current flows in the main circuit, is mounted on the cover slab of the oil switch. It consists of two alternating-current electro-magnets fed by transformers in the main circuit. Between the poles of each of these magnets swings a metal sector. The field produced by the magnet tends to move

the metal sector, which is counterweighted, and which carries a contact that closes the tripping circuit of the control switch when the main current exceeds a certain value. The two sectors are connected in parallel; each of the sectors alone is able to open the circuit.

In the illustration accompanying, the arrangement of the parts of this oil-switch can be seen. The three compartments are shown in different conditions: the one on the left with its iron door closed, the middle one with the door removed showing the oil-tank in place, and the one on the right with the oil-tank removed. It should be said that each oil-tank has a gage glass to show the amount of oil contained in the tank; the tanks are made of sheet metal and are lined with insulating cement. On top of the brick structure will be seen the crosshead and operating levers, with the toggle and tripping lever and magnets at the left, and at the right a spring to pull the crosshead down quickly in opening the circuit. In the center is the overload relay, showing the magnets and sectors. Behind this relay, barely visible in the picture, is the magnet for lifting the crosshead (i. e., closing the circuit). The other devices mentioned, the control switch and the indicator, are not shown, being part of the switchboard equipment.

The main contacts of the oil-switch, when the circuit is closed, are made by the U-shaped copper piece and the copper rods, as already mentioned. The break, however, is not made here but occurs at removable plugs, attached to the main terminals, which are adapted to enter holes in the movable contact. These plugs leave the holes in the removable contact after the circuit through the main contact surfaces of the rods has been broken, and thus all arcing takes place at the plugs, which being removable can readily be renewed.

AN ELECTRIC-SPEED CONTROLLER ATTACHMENT TO A WATER WHEEL GOVERNOR.

A useful attachment to water-wheel governors controlling hydraulic motors used to drive alternators in electric power stations has just been brought out by the Lombard Governor Co., of Boston, Mass. It consists of a small electric motor arranged to lengthen or shorten the valve stem of the governor, and thus to lower or raise the speed of the turbine corresponding to a given position of the centrifugal balls. The motor is similar to those used for driving electric fans. The connection of the motor to the right and left threaded coupling which draws the two parts of the valve stem together or forces them apart is by a worm and gearing, giving a very large speed reduction, so that the actual power required by the motor is trifling; probably not more than 1-100 HP. at a maximum, and that only for a few moments. Thus the motor can be run with two or three cells of a dry battery, where it is not convenient to connect it to the exciter circuit.

The apparatus can be attached in a few minutes to any of the Lombard governors now in service and does not interfere in any way with the normal control of the valve by the governor.

In use the motor is controlled by two small push-buttons, which may be placed at any desired point, a 3-wire circuit being led from them to the motor. Usually these buttons are placed on the station switchboard, where they are convenient to the operator in bringing an alternator up to speed and synchronizing it to throw it into parallel. Inasmuch as these two push buttons act to instantly raise or lower the speed of the generator, it will be seen that the operator can bring the generator to exact speed by them without taking his eyes off the synchronizing lamps and without the aid of an assistant.

Another important governor attachment recently brought out by the Lombard Co. permits turbines to be stopped or started by merely pressing an electric push-button, which may be located at any distant point, or if desired a number of such push-buttons, to stop the turbine, may be placed at various points in a factory for use in case of emergency. A somewhat similar apparatus is arranged to start the turbines automatically whenever the exciting current is turned into the generator fields, and to stop them automatically wherever the field circuit is broken.

THE ORGANIZATION FOR CONSTRUCTION OF THE PENNSYLVANIA R. R. EXTENSION IN NEW YORK CITY.

The engineering organization to prepare and carry out the plans for the extension of the Pennsylvania R. R. onto Manhattan Island and its terminal there has been perfected. The commission in charge of the tunnel work consists of Col. Charles W. Raymond, Corps of Engineers, U. S. A., Chairman; Charles M. Jacobs, Chief Engineer North River Section; Alfred Noble, Chief Engineer East River Section; William H. Brown, Chief Engineer Pennsylvania Railroad, in charge of tracks and terminal yards; Gustav Lindenthal, Bridge Commissioner of New York city; George Gibbs, First Vice-President of Westinghouse, Church, Kerr & Co., in charge of mechanical engineering, electric locomotives and traction.

The firm of Westinghouse, Church, Kerr & Co. has been placed in charge of the mechanical and electrical engineering work, in connection with the new lines, and the firm of McKim, Mead & White are to be the architects.

The Pennsylvania Railroad officials thus deal directly with three organizations: The engineering commission; the firm of architects; and the Westinghouse firm as engineers. Harmonious co-operation between these organizations is ensured by the representation of the Westinghouse firm on the Commission, and by the attendance of Mr. Mead on the Commission's meetings.

Within the Westinghouse, Church, Kerr & Co. organization has been formed a special Pennsylvania Railroad Terminal Committee, meeting at regular intervals and representing in its membership the various branches of engineering involved.

Thus far the active engineering work has consisted chiefly of investigations concerning the relative feasibility of different plans. Thus there is being perfected by study, design and elimination a final set of plans which will come before the management of the Pennsylvania Railroad for final approval, and upon which the work of construction will then proceed.

The Commission has been at work since early last spring, while the architects and engineers have had a large corps of men actively engaged since last June.

The engineers have already substantially completed the plans for the Long Island power house, so that work can be begun immediately upon the same; this was necessary in order to provide electric power for the Atlantic Avenue Division of the Long Island R. R. (described in Engineering News of Dec. 18), which will be ready for operation much earlier than the Pennsylvania R. R. tunnel lines. This power house, together with the one in New Jersey, will jointly serve the entire terminal system, and each will have provisions for relaying the other and for serving the New York Terminal station singly or jointly.

It may be noted as illustrating the magnitude of the work to be done on Manhattan Island, that besides the terminal station proper an area of about 500 × 800 ft. between 7th and 9th avenues will have to be excavated to a depth of 40 to 50 ft.

FORESTRY ON WATER-WORKS DRAINAGE AREAS.

Forestry in the United States seems a thing of yesterday, but already a good beginning in seed and tree planting has been made in the drainage areas of a number of water-works. The Metropolitan Water and Sewerage Board (Boston and vicinity), the cities of Woonsocket, R. I., Hartford and Middletown, Conn., and the private water companies supplying New Haven, Conn., and Johnstown, Pa., have made beginnings in forestry work, although the Johnstown Water Co. has done no planting as yet. In addition, some work of a similar character, mostly in the way of projects, has been done in the Far West, as outlined at the end of this article.

From the information in hand it appears that the first forestry work on an extensive scale ever done in the drainage area of an American water supply system was started in 1898 by the Metropolitan Water Board, the predecessor of the present Water and Sewerage Board. In any event, this work will be described first, and the other efforts will be outlined in geographical order.

THE METROPOLITAN WATER AND SEWERAGE BOARD.—In its report for the year 1900 the work done during the year by the predecessor of this board is described as follows:

A fire line 40 ft. wide has been cleared off around the margin of land purchased by the board for 37,230 lin. ft., in order to have an open space for the purpose of fire protection. There have been 22.9 acres of woodland cleared, the underbrush cut and in some cases burned; 1.9 acres have been cleared and grubbed for a nursery on the south side of the reservoir. Twelve bushels of sugar maple seeds, 12½ bushels of white oak acorns and 1½ bushels of chestnuts have been gathered; 56,504 sq. ft. have been planted with maple seeds, 15,030 sq. ft. with white oak acorns, and 880 sq. ft. with chestnuts at the nurseries. There have been 1,793 pine trees, from 1 to 6 ft. in height, taken from below the flow line near Sawyer's Mills and set out on the margin of the reservoir near the north dike; 6,850 pine trees, from 1 to 6 ft. in height, have been taken from the southerly arm of the reservoir below the flow line, and set out along the south side of the reservoir in Boylston; 175,000 pine seedlings and 200 sugar maple seedlings have been transplated at the nurseries.

In the report for 1901 it is stated that old and new fire guards were cleared during the year, and that in extremely dry weather a fire patrol was kept up. Thinning for improvement was done on 123 acres of land, 103 acres were cleared preparatory to tree planting the next spring, and 1½ acres had been

cleared and grubbed for extending the nurseries on the south side of the reservoir; making the total area of tree nurseries under cultivation about five acres, on two acres of which white pine seeds have been planted during the year.

At the close of the year the nurseries contained 685,000 white pine seedlings, of which 100,000 were from seeds planted in 1898; 70,000 from planting in 1899; and 515,000 from planting in 1901.

All this work has been done on the margins of the new Wachusett Reservoir, which will be formed by the immense dam across the Nashua River, at Clinton, Mass., now being built by the board. Mr. Frederic P. Stearns, M. Am. Soc. C. E., is chief engineer of the board, and Mr. Hiram A. Miller, M. Am. Soc. C. E., is engineer of the reservoir department. Mr. Miller has kindly outlined for us the forestry work done during the first eight months of 1902, as follows:

Since Jan. 1, 1902, approximately 175 acres of old pasture land has been planted with white pines and sugar maples, rows 5 ft. each way. The method of mixing has usually been as follows:

Pine	Maple	Pine	Maple
Maple	Maple	Maple	Maple
Pine	Maple	Pine	Maple
Maple	Maple	Maple	Maple

This mixture required 435 pine and 1,307 hard maple seedlings to the acre. The pines were taken from seedlings grown in the nurseries. The sugar maples were natural seedlings pulled from the pure hard maple forests in Tolland, Mass. The other work during the year has been care of the seedlings in the nurseries, fire protection, etc.

In a still later communication to this journal Mr. Miller states:

Arrangements have been made for planting in the spring of 1903 two hundred acres of old pasture and mowing lands, using white pines and sugar maples in the same manner as was used in the spring of 1902.

In addition to the foregoing statements we are informed by Mr. B. E. Fernow, Director of the New York College of Forestry, Cornell University, that the planting work at or near Clinton is now being done under the immediate direction of Mr. Theo. F. Borst, a graduate (1901) of the college just named; while Mr. Overton W. Price, Acting Forester, U. S. Bureau of Forestry, states that a plan was made for the board in 1901 by the Bureau of Forestry.

MIDDLETOWN, CONN.—The water commissioners recently secured control of some farm lands on the east side of its new reservoir on Higby Mt. On such of the land as would not produce a paying crop of hay it was decided to put out seedling trees, instead of allowing the uncontrolled reëstablishment of forest conditions. In the report of the water commissioners for 1901 it was stated that, as an experiment, "saplings taken from the woods" were set out, besides which some seedling evergreens were planted, making a combined number of 451. The difficulty and cost incident to obtaining and transplanting saplings being so great, nurseries were established at points convenient to the land to be devoted to forestry. In 1901, seeds of black walnuts, oaks and hickories were planted. The conditions existing on Nov. 20, 1902, have kindly been stated for us by Mr. J. C. Broatch, Superintendent of Water-Works, as follows:

We have about 30,000 white pine and a large number of

black walnut, oaks and hickories raised this season. This plan of raising the stock for planting will be followed every year until the watershed is planted with the selected varieties of trees for timber culture. Our board of water commissioners has made a written agreement with the Agricultural Experiment Station, at New Haven, Conn., which have charge of the state's forestry work, whereby the latter will co-operate in this work by making a planting plan and superintending the work of planting when necessary. The board has agreed to expend for this purpose not less than $200 per year for five years from Jan. 1, 1903. This agreement was brought about by Mr. Walter Mulford, F. E., State Forester.

These open fields are being planted with white pine, red oak, maple and other valuable species, in order that they may be brought, as soon as possible, under forest cover. The forest is being carefully thinned with a view of utilizing the dead, dying and defective material, and of improving the conditions of the forest by removing individuals which are crowding their more valuable neighbors. The planting involves the expenditure of some money, which is fully justified financially by the returns which can be obtained in the future, and is of particular importance from the influence of the forest as a protective cover. The work of thinning is yielding very satisfactory financial results.

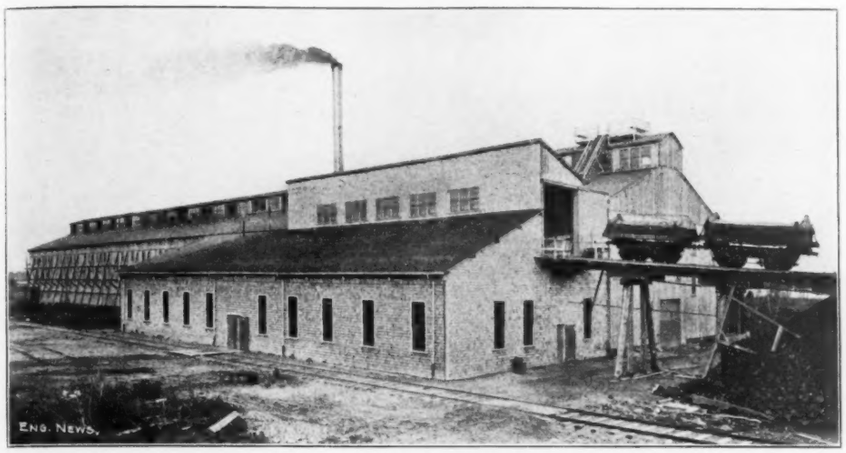


FIG. 1. EXTERIOR OF FACTORY OF THE FISKE BRICK CO., DOVER POINT, N. H.

Mr. Mulford has made surveys and examined the soils and conditions of all of the farm lands in question for the purpose of making a planting plan. There are about one hundred acres of these bare lands still retaining the fence division into lots, and each lot is treated separately in the plan. We also have large areas of woodland on the mountain slope, west of the reservoir, and it is proposed to gradually improve the conditions there by subjecting these wood lots to forestry treatment. Mr. Mulford will probably undertake some of this work very soon. We have been gathering a few varieties of tree seeds, and storing them in the ground, to be used in planting in nursery beds next spring.

We are informed by Mr. Mulford that he has already completed a planting plan for nearly fifty of the fields mentioned by Mr. Broatch. Mr. Mulford also states that to Mr. Broatch belongs the principal credit of inaugurating the work at Middletown. We may add that Mr. Mulford, like Mr. Borst, is a graduate of the New York College of Forestry, which now gives the degree of Forestry Engineer.

WOONSOCKET, R. I.—The work here, we are informed by Mr. E. W. Kent, Superintendent of the water-works, is thus far limited to a proposed shelter belt of 8,000 or 10,000 conifers for some farm buildings. We understand that the seedlings have been bought at the rate of $6 per 1,000, and are being planted this fall.

Mr. Price, whose name was just mentioned, has written to us about this work as follows:

> The plan for the planting on Woonsocket watershed was made this summer by Mr. Wm. L. Hall, Chief Division of Forest Extension of this Bureau, and planting was begun this fall under the supervision of E. A. Sterling, Field Assistant in the Bureau of Forestry. The land to be planted consists of open fields near the reservoirs.

NEW HAVEN AND HARTFORD, CONN.—The conditions at these places are thus described by Prof. Henry Solon Graves, Director of the Yale Forest School, New Haven, Conn., in a letter to this journal dated Oct. 3, 1902:

> The New Haven Water Co. has placed a portion of its land in charge of the Yale Forest School. This land surrounds three of the company's reservoirs. Most of it is covered with forest, but there are also several open fields.

The situation at Hartford is similar, except that the entire tract has been placed under forest management instead of only a part. I, personally, have the general direction of the forest work, but the water board employs a resident forest ranger who has immediate charge of the work. The land will be protected from fire by a system of keeping the wood roads cleared. About 650 acres of open land will be planted with valuable kinds of trees, and the wooded portion of the watershed will be treated in the manner described for the New Haven watershed. About 150 acres will be thinned out the first year.

Mr. F. D. Berry is Secretary of the Board of Water Commissioners of Hartford.

JOHNSTOWN, PA.—The Johnstown Water Co., in 1900, bought nearly 2 of the 5.5 sq. miles of the drainage area of Mill Creek, above the company's reservoir. In December, 1900, Mr. A. H. Walters, then secretary of the company, stated that the company wished to buy all the cleared and cultivated lands in the drainage area, but some of the owners demanded excessive prices, and the statutes of Pennsylvania do not, or did not then, permit the condemnation of land for the protection of water supplies. Mr. Walters also stated that his company had consulted Messrs. Toumey and Graves (then) of the Forestry Division of the U. S. Department of Agriculture, on the reforesting of the land bought and that it would "at an early date follow their suggestions in this matter." Professor Graves, in the letter from which we have already quoted, states:

> Professor Toumey and I made an examination of the watershed at Johnstown, Pa., several years ago, but I think they have not begun practical operations.

We are informed by Mr. W. H. C. Ramsey, Secretary of the Johnstown Water Co., that up to December, 1902, no planting has been done, but that numerous locust trees have sprung up on the cleared ground and are doing well.

IN THE WEST.—In response to a request for further instances of forestry work on water-works drainage areas we have received a letter from Mr. F. H. Newell, M. Am. Soc. C. E., of Washington, D. C. Chief Engineer of the U. S. Geological Survey, from which the following extracts are taken:

> The additional cases which occur to me are the creation by the Government of the Bull Run Forest Reserve, to protect the water supply of the city of Portland. The facts concerning this reservation can probably be ascertained from the Superintendent of Water-Works, Portland, Oregon.
>
> The city of Salt Lake has, I think, a tract of land, either purchased or reserved on the headwaters of City Creek, and is doing something towards reforesting this area.
>
> The Denver Union Water Co. is protecting the area tributary to Lake Cheesman and has been discussing the feasibility of planting or seeding the lands around the lake.
>
> The Spring Valley Water-Works Co., of San Francisco, has, I think, encouraged tree-growth on the catchment areas tributary to its streams.
>
> The city of Los Angeles has been prominent in urging Federal authorities to protect the forest reservation around the headwaters of Los Angeles River.

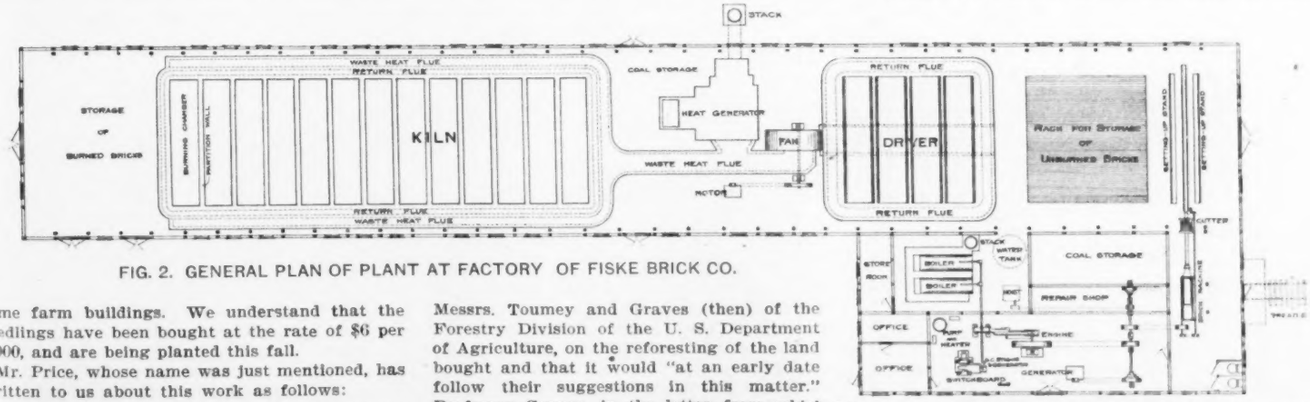


FIG. 2. GENERAL PLAN OF PLANT AT FACTORY OF FISKE BRICK CO.

THE ELIMINATION OF HAND LABOR IN BRICK MAKING.

By J. Parker B. Fiske, S. B.†

All observing persons will agree that the manufacturing world has practically been revolutionized within the last quarter of a century by the use of labor-saving machinery. Hardly a class of manufacture exists that has not felt its magic touch, and with its aid the United States has become the foremost manufacturing country in the world. A manufacturer in nearly any industry who should return to the practice of even ten years ago in preference to that of to-day would invite failure and bankruptcy.

This is the age of machinery—automatic machinery, often with the most intricate mechanism, which works with marvelous speed and accuracy and which accomplishes tasks far beyond the capability of the human hand, both in quality and quantity of product manufactured. As a result of such machinery, the cost of nearly all manufactured articles has been enormously reduced and the consumption by the people correspondingly increased.

It is the purpose of this paper to discuss the application of machinery to the art of brick making, with a view to the practical elimination of hand labor.

Much ingenious and useful brick machinery has already been invented and is in daily use in hundreds of plants; this is, however, largely confined to the preparation and handling of the clay and the forming of the soft bricks. This machinery has been perfected to such a point that little improvement is needed or can be expected in future, and the same remarks are doubtless true of the most modern types of drying and burning devices.

No successful attempt has been made, however, so far as I am aware, to eliminate the manual labor involved in handling the bricks from the brick machine through the various processes of drying, burning, storing and delivery to the user, and inasmuch as this labor of handling constitutes a large part of the entire labor involved in the manufacture, comparatively little saving has been effected in the total labor cost.

Certain improvements, such as the various car and truck systems, have come into use to a large extent, but these have been adopted mainly because of their convenience and adaptability to the artificial dryer rather than as labor-saving devices pure and simple. These devices must still be propelled over long distances by man power and the bricks, even under the most favorable conditions, must undergo repeated handling in setting and emptying the kilns and in loading the delivery cars or wagons.

The number of hand operations in modern brick making varies greatly, depending upon the process, whether molded by the "soft mud" or the "stiff mud" machines,

*Reprinted by permission, from advance sheets of Volume V. "Transactions of the American Ceramic Society."

†Vice-President, the Fiske Brick Co., 164 Devonshire St., Boston, Mass.

whether dried on the open yard in racks or in artificial dryers, and whether burned in up draft, down draft or continuous kilns. It is fair to say, however, that an average of all plants would show from 12 to 15 hand or man-power operations, from the time the bricks are molded until they are loaded on the delivery wagons.

When the value per ton of the finished product is taken into account this amount of hand labor appears excessive; thus a ton of common bricks is worth on the average say $2.50 on the wagon or cars at the plant, while a ton of steel rails at $20 has excited the wonder of the whole world. Such a low value should involve a minimum of hand labor per unit of weight, yet it is doubtless true that no finished product in the world involves so much. In short, an excessive proportion of the entire cost of brick making to-day is in the labor item, and our only hope of substantial reduction lies in the minimizing of this hand labor.

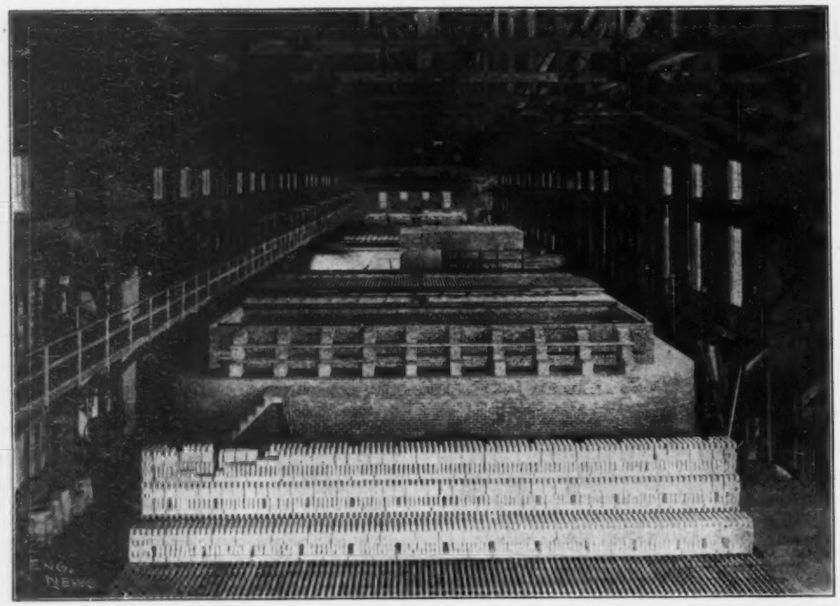


FIG. 3. BIRD'S-EYE VIEW OF INTERIOR OF MAIN BUILDING, SHOWING STORAGE RACK FOR DRIED BRICK IN FOREGROUND.

The prime necessity for the successful use of automatic machinery in any art is that every unit of manufacture shall be subjected to precisely the same treatment, and this condition obtains to an ideal extent in the art of brick making. Thus, particularly in the case of common bricks, every piece is molded or pressed exactly like its mates, and is subjected to the same drying and burning heats and, theoretically, when finished should be of exactly the same size, shape and texture.

However, a careful study of this problem will, I think, convince anyone that no great improvement can be made in the "summer brickyard," that is, one in which the drying is done by sun and wind, as these elements are intermittent in their action and are so uncertain at best that manufacturing can be conducted not over one-third of the total number of working days in the year. It is also important for the profitable use of lavor-saving machinery that it shall be worked systematically and continuously in order that it may have an opportunity to earn a fair interest on its first cost, which is necessarily high. To make any radical improvements, therefore, the "open yard" idea must be abandoned and a permanent, substantial construction must be adopted, with the best possible form of brick-molding machinery, artificial dryers and fuel-saving kilns, specially constructed to suit the new conditions involved in the use of automatic handling machinery, the whole plant representing a comprehensive scheme, complete in all its arrangements, so that the raw material may enter at one end, proceed systematically through the various processes and emerge a finished product at the other, practically without hand labor.

Having perfected such a system and put it into successful operation at the works of the Fiske Brick Co., at Dover Point, N. H., I take pleasure in presenting a description of it to this society.

Fig. 1 shows the exterior of the main building, with monitor roof, being 367 ft. long and 60 ft. wide, and the auxiliary building being 115 ft. long and 50 ft. wide.

Fig. 2 is a plan view of the plant thus far erected, and shows:

Power plant, consisting of two tubular boilers, pumps and feed-water heater, a 200-HP. Corliss engine, 50-KW. belted dynamo, 50-KW. direct-connected engine and dynamo as a spare unit, switchboard, shafting, etc.

Brick machinery, consisting of a Chambers disintegrator and a Freese combined pugmill and auger machine for making stiff mud bricks, with an automatic cutter and an off-bearing belt extending nearly across the main building.

Setting-up stands for the reception of the green bricks as they are taken from the belt.

Drying arrangements, consisting of a Crown heat generator, a 12-ft. Sturtevant fan and four drying chambers of special construction, as described later.

Kiln, consisting of 13 chambers arranged in one battery for burning by the continuous or regenerative principle.

Fig. 3 is a bird's-eye interior view looking north and shows the storage rack and dryer in the foreground.

The clay is drawn up an inclined trestle in side dumping cars, each of 5 yds. capacity, and is dumped into a hopper at the disintegrator. The material proceeds through the disintegrator, brick machine and cutter, and the green bricks pass out into the main building on the off-bearing belt, all in the usual manner.

At this point in the manufacture the special handling machinery begins its work, the process thus far being an entirely standard one.

Careful consideration of the conditions necessary for the drying and burning of bricks has convinced me that the successful handling machinery must handle the bricks in large masses rather than one by one, as is done by labor-saving machinery in most other arts, and I consequently introduced at this point in the manufacture what I term the "unit stack" idea, which I believe to be entirely novel in brick making.

The unit stack consists of a pile of bricks built up, as they issue from the molding or pressing machine, in such relative position, brick to brick, that they can be dried, burned and loaded on the delivery car or wagon without rearrangement, the entire stack being lifted as a unit, transported and deposited by suitable machinery, first into the dryer, then into the kiln, and finally into the stockyard or delivery wagon. The original stacking can be done automatically, layer upon layer, by machinery, or can be done by hand as in the plant under discussion.

The unit stack system creates a distinct advance in the art, as it eliminates all manual handling after the bricks are once stacked, banishes from the brick factory all tip carts, trucks, wheel-barrows, drier cars, tracks, transfer cars and turntables, dispenses with kiln "setters" and "emptiers" and reduces the entire force of employes, beyond the brick-machinery gang proper, to a mere handful of men.

In order to place the bricks in unit stack formation, a rack called a "setting-up stand" is permanently located on each side of the off-bearing belt, and at a suitable distance therefrom to accommodate the stackers.

Fig. 4 shows the setting-up stands, constructed with 105 heavy horizontal bars of hard pipe, mounted at a convenient height for the stacking of the bricks, these bars being spaced apart so as to support each lower brick at its two ends and in the middle, leaving two clear spaces about 1½ ins. wide under each bottom row. The bricks may be set five over two, six over two, or in any manner required for their proper drying and burning, exactly as is done in the usual plant, and no more care is required than in setting bricks in an ordinary kiln. For these reasons a very wide variety of clays can be handled by this system as any style of setting may be adopted which is found necessary to suit the peculiarities of the clay in question.

The stand in about 39 ft. long by 20 ins. wide and holds about 1,500 bricks when stacked five over two (that is, five headers over two stretchers) and six courses high. At the back of the stand are vertical guide bars, also of hard pine, to insure a perfectly vertical stack and to guide the stackers in setting the top row of bricks, which must be spaced exactly to correspond with the horizontal bars, as will be seen later.

As soon as the first stack is completed, the stackers commence placing the bricks on the opposite stand, the first stack being soon removed by the handling machinery, thus leaving the first stand empty and ready for another stack. Thus all waiting for empty cars or trucks, as is common in many brick plants, is eliminated, and the brick machine is free to run without interruption. Fig. 4 shows one stand filled and the other partially filled.

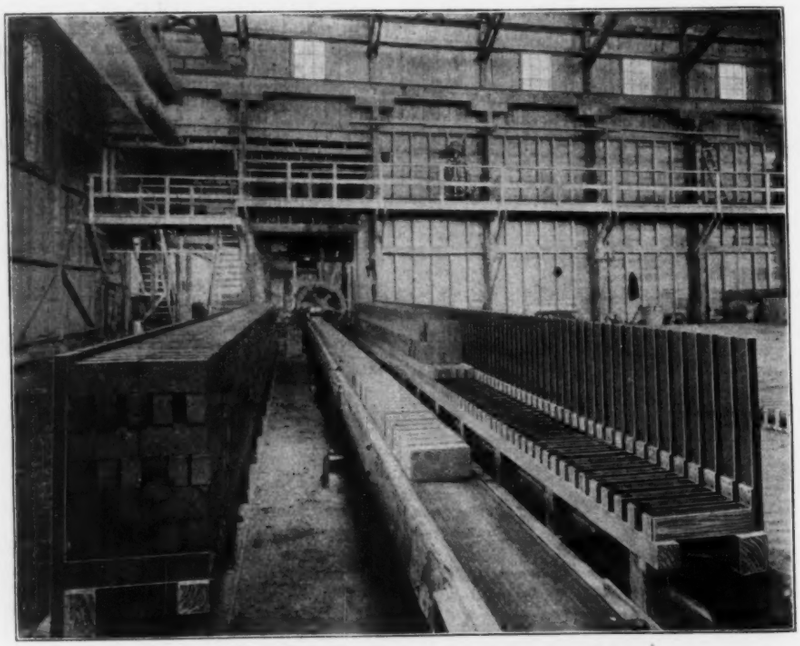


FIG. 4. VIEW OF "SETTING-UP STANDS" FOR STACKING BRICK.

(One stand is filled with soft brick and one is partly filled; the belt carrier bringing the soft brick from the machines is between the stands.)

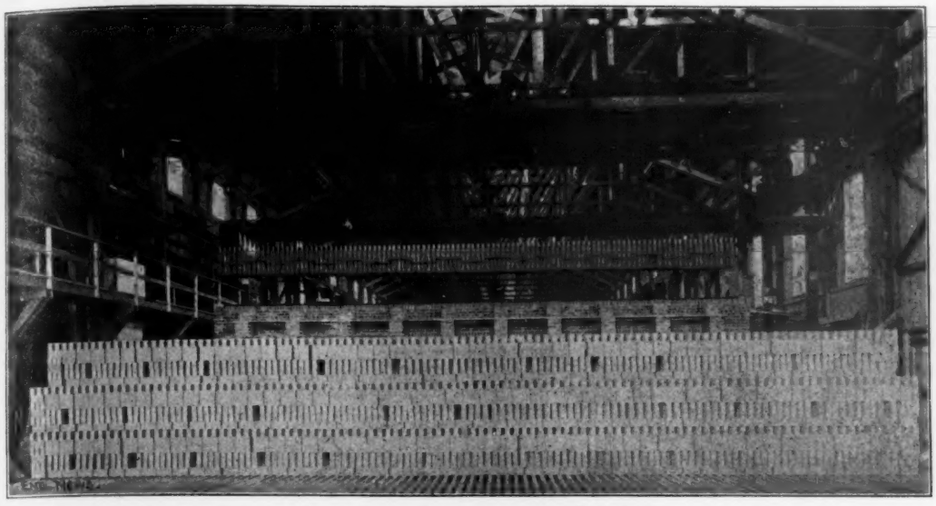


FIG. 5. TRAVELING CRANE CARRYING A STACK OF SOFT BRICKS TO THE DRIER. DRIED BRICKS IN STORAGE IN THE FOREGROUND.

The handling machinery consists of an overhead electric traveling crane and a special carrier called a "brick lift." By reference to Fig. 5 it will be seen that the crane travels on tracks supported on an elevated runway near the eaves of the main building, and that it spans this building completely and travels its entire length. The crane is driven along the overhead tracks by an electric motor called the "travel motor," located midway on the crane girder and shown in the cut, and the hoisting and lowering of the load is effected by the "hoist-motor," located on top; each motor is controlled independently by a lever in the operator's cage. The hoisting is done by four vertical chains and four winding drums driven in unison by the main shaft from the hoisting motor.

The brick lift consist of two main lifting beams properly braced together to form a girder; to this girder are attached 104 lifting fingers accurately spaced apart to correspond to the spaces between the bars of the setting-up stand, so that the whole forms a rigid structure. The four vertical chains already mentioned are attached to four lifting eyes on the lifting beams, thereby securing the utmost stability of the loaded lift, tipping in any direction being impossible and swaying and twisting being reduced to a minimum.

To engage and transport a load of bricks, the lift is brought by the crane in front of the setting-up stand, lowered until the fingers are at the proper level, the crane moved forward until the horizontal members of the fingers are run into the spaces between the bars of the stand and underneath the lower layer of bricks. Fig. 6 shows the fingers in the act of entering these spaces. The lift with the entire load of bricks is then raised clear of the stand by the hoisting motor, and is carried by the crane to the dryer as a unit.

By reference to Fig. 7, it will be seen that each brick of the bottom layer is supported on two fingers of the lift, hence there is perfect stability of the load and it is impossible for it to twist or topple over. Repeated trials with the most violent movements of the crane that were possible have failed to dislodge a single brick from its load.

The crane operator is located in a cage at one end of the crane, as shown in Fig. 5, and at all times has an uninterrupted view of the runway and of his work below.

It will be noted that this operator, with one helper on the brick lift, can handle as many bricks at a time as 15 to 20 men with wheelbarrows, and that the speed of travel along the tracks is faster than a man can comfortably walk.

Handling the unit stack during the remainder of the process is accomplished by the use of racks in the drier, kiln and store room, each constructed with horizontal members accurately spaced for the reception of the bricks as in the case of the setting-up stand and provided with spaces between its members to correspond to the fingers of the lift. Thus in the dryer these racks are of steel I-beams, in the kiln they are of bricks to withstand the heat necessary for burning the ware, and in the storeroom they are of either steel or wood.

The dryer shown in section in Figs. 7 and 8 is of brick and steel construction, is absolutely fireproof and is novel throughout. It is divided into four chambers by permanent partition walls, each chamber being provided with a cover removable in one piece; these covers are constructed of I-beams with an upper and lower covering of sheet iron, thereby providing a dead air space of about 4 ins. Fig. 9 shows one of these chambers with the cover removed, two stacks of soft bricks having been placed in the chamber.

In the bottom of each chamber is a fixed rack of I-beams constructed as already described; the stacks of bricks are brought from the setting-up table and deposited successively upon this rack, the brick lift being lowered through the rack to deposit the bricks, and being backed out and raised from the rack each time after so depositing them.

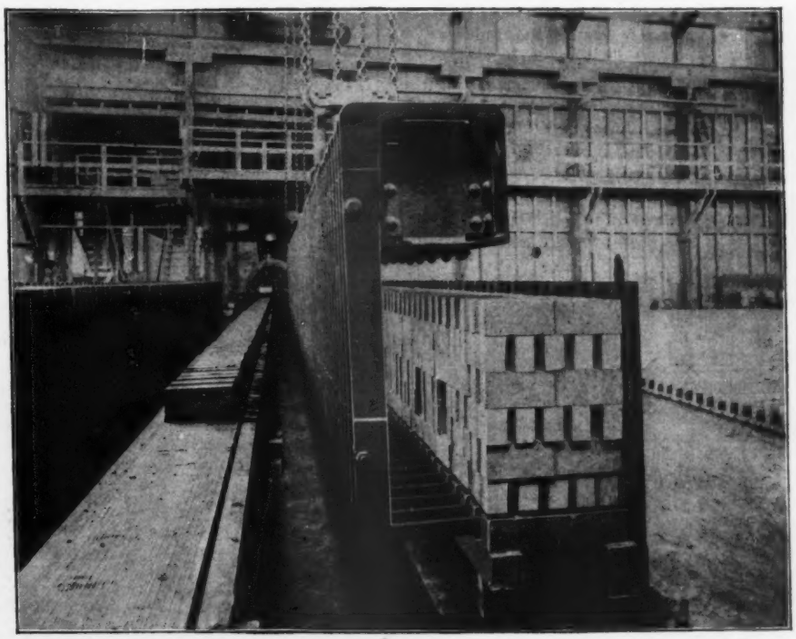


FIG. 6. FINGERS OF THE BRICK LIFT ENTERING THE SETTING-UP STAND TO LIFT A STACK OF SOFT BRICKS.

As the soft bricks will not bear the weight of superimposed loads, each chamber is provided also with two removable racks, which are supported by horizontal channel beams built into partition walls separating the chamber. Each removable rack is built of I-beams like the fixed rack below it, and each holds four stacks of bricks, thus making the capacity of each chamber 12 stacks, or about 18,000 bricks.

The arrangement of the covers and the racks with their loads of bricks is clearly shown in Figs. 7 and 8.

The method of handling the removable racks by the crane is shown in Fig. 10. Each rack is provided on its under side with two flat iron bars running lengthwise and equi-distant from the center line of the rack. The fingers of the brick lift are dropped below the level of these bars and are then run under them so that the rack can then be lifted and transported, the bearing on the two bars preventing the rack from tipping or twisting.

The covers are provided with latticed lifting beams attached to the tops so that the fingers of the lift can be run under them for the purpose of handling the covers from one chamber to another. A cover is generally removed from a chamber of dried bricks and placed upon a chamber just filled with bricks to be dried. Each cover, when in position, is supported by channel irons on the top of the partition walls, as shown in Figs. 7 and 9, these channels being filled with sand; a downwardly projecting lip on the cover imbeds itself in this sand when the cover is placed in position, thereby automatically sealing the chamber.

Hot air is forced through the bricks by a powerful fan driven by an electric motor, the air passing through three chambers in succession, as shown in Fig. 8. Inasmuch as the bricks cannot be progressed through successively hotter and hotter zones, as in the case of the tunnel dryer the same results are obtained by progressing the zone of maximum heat through the bricks. Thus the air being heated by a suitable device, in this case by a Crown heat generator, it is forced into a circular tunnel running lengthwise of the building and passing under the center of each chamber, as shown in Figs. 7 and 8. On each side of this tunnel and under each chamber is a large open-

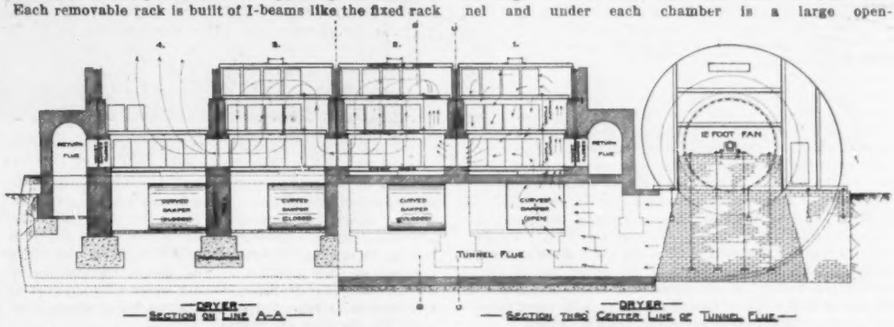


FIG. 7. LONGITUDINAL SECTION OF FAN AND DRIER CHAMBER.

ing, closed by a curved hanging damper controlled by a chain from the outside of the dryer. This opening admits just the proper amount of air to a distributing compartment located beneath the lower brick rack and provided with a sloping bottom to insure a proper flow of air into all parts of the drying chamber. The curved dampers being closed under all the chambers except the one of nearly dried bricks, the air passes from the tunnel into the distributing compartment, and thence upward through the bricks.

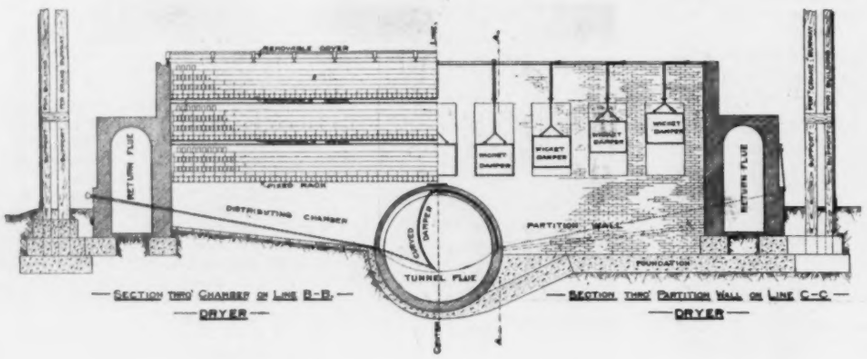


FIG. 8. CROSS-SECTIONS OF DRIER.

In order to facilitate the proper circulation, a wide space is left between the bricks at one side of the chamber and the partition wall, this space being insured by the room necessary for backing out the brick lift after depositing its last load on each rack. In the case of the lower rack, a wide sheet iron floor is attached to the lower side of the rack, underneath that portion covered by the bricks, in order to force all the air first into the clearance space and up to the cover, and thence downward and at more or less of an angle through the bricks to openings or wickets in the base of the opposite partition wall, and thence into the next chamber. To prevent the air from passing directly through the lower tier of bricks to the wickets, canvas baffle curtains are hung from the bottom of the two movable racks, thereby forcing the air up, over and then downward through the bricks. The wickets are closed by vertical sliding dampers, controlled by chains passing upward through 2-in. pipes imbedded in the partition walls.

The hot air is first admitted to a chamber of nearly dried bricks and passes thence to a partially dried chamber, thence to a chamber freshly filled and finally into an open chamber just being filled. As soon as the first chamber has been thoroughly dried and the last chamber has been filled, the cover of chamber No. 1 is removed, and is placed in position on No. 4, the hot air is shut off from the No. 1 and admitted directly to No. 2, which by this time has become sufficiently heated and dried to prevent checking of the ware. Chamber No. 1 is now ready to have its brick removed to the kiln for burning. Chamber No. 4 is connected with chamber No. 1 by return flues, located on either side of the drier in order that the chambers may operate in rotation without any interruption, as in the case of the continuous burning kiln.

Thus the zone of maximum heat is progressed from chamber to chamber, the nearly dried brick receiving the maximum heat and the green bricks being subjected to warm moist air as in the most approved types of progressive artificial driers.

The bricks are carried from the dryer to the kiln by the crane and brick lift, and are there deposited, each chamber (holding about 18,000 bricks) having a removable crown, so as to leave the entire top open. The bottom of the kiln, or that portion covered by bricks to be burned, is provided with a special fire-brick floor with separated ribs, corresponding in spacing to the fingers of the brick lift, so that the stack of dried bricks is deposited without difficulty and the lift withdrawn as in the case of the dryer, each brick of the lower layer being supported by the ribs of the floor at its two ends and in the middle. Fig. 11 shows a load of dried bricks going into the kiln, and Fig. 12, taken during the construction of the kiln and before the partition walls were built, shows the brick lift in the act of depositing a load of bricks on the ribs forming the special kiln bottom.

After the four stacks of bricks forming the lower tier have thus been placed in position in the kiln, other successive stacks are placed upon them, the fingers of the lift passing down into the spaces of the upper row of bricks of the tier below. It will be noted that the upper row of bricks of each stack is spaced especially wide apart to permit this operation, as has already been described.

The setting consist of three tiers of four stacks each. After placing the last stack in position the empty lift is backed out into the "combustion space," and is then withdrawn from the kiln. In reverse manner, the lift enters the kiln when the bricks have been burned and cooled and removes one load after another to the point of shipping or storage.

After the kiln chamber is filled with bricks it is ready for the reception of the portable crown.

The kiln operates on the "semi-continuous" principle, and is built with permanent transverse partitions, dividing it into chambers; the fires are fed with coal through holes in the crown and are supplied with hot air from the cooling chambers behind, the air entering the burning chamber through the "wickets" in the base of the partition wall; the waste heat of the burning chamber passes forward in a similar manner to heat up the green bricks in advance of the fires. Thus the utmost economy of fuel is secured.

Many novel features are to be noted in the construction and operation of the kiln under discussion. The chambers are unusually low and narrow, which enables them to be fired largely from one side and to produce a very uniform burn. The open space above mentioned acts not only as a combustion chamber, but provides an entrance and exist for the brick lift to the chamber when the latter is filled with bricks.

The removable crown for the kiln chambers are constructed of fire clay blocks and cast-iron hollow beams of special shape and section. These beams are spaced about 18 ins. apart by separating bolts and span the kiln chamber from one partition wall to the next, the ends resting on special cast-iron channel irons anchored along the top of the partitions. The beams support heavy blocks, made of high-grade fire clay mixed with sawdust to give porosity, the soffits of the beams being amply protected by fire clay key pieces.

The crown is sealed around the edge with soft bricks and sand and gives a construction of great superiority over the ordinary mason work arch. No lateral thrust of any kind on the side walls or partition walls is produced as the crown expands and contracts, the iron beams simply sliding on the channel iron supports. Moreover, repairs may be made to a crown by removing one or more fire clay blocks without tearing down the whole crown, and without interrupting the operation of the kiln, as is often the case in ordinary fire-brick construction. The crowns are lifted, transported and deposited by the crane and the brick lift, which engages a heavy latticed lifting girder attached to each iron beam of the crown. This construction provides a liberal amount of flexibility and secures a satisfactory seating of each beam on the wall without undue straining of the fireproofing materials. The construction of the crowns and the manner of lifting them are shown in Fig. 13.

As all filling and emptying of the chambers is done through the top, the kiln is built with thick, permanent and unbroken side walls, all arched doorways being omitted. Thus the necessity of continually bricking up and tearing down the doors, as in other kilns, and the usual complement of soft-burned bricks near the doorways are obviated. Moreover, as the side walls are unbroken from end to end, it is possible to build the kiln with all flues in the walls, thereby eliminating the underground flue absolutely. As is well known, underground flues are often cold and damp and are a source of great irregularity of draft, particularly in a continuous kiln, where the temperature of the waste gases is very low.

The draft for burning is produced by an exhaust fan driven by an electric motor, the whole being mounted on a portable cover, constructed of I-beams and sheet-iron covering, as in the case of the dryer covers. A suitable iron pipe connects the inlet of the fan with holes through the cover at the proper points. The draft cover is transported by the crane and brick lift, which engages a lifting beam, as will be seen by reference to Fig. 14. The draft cover is deposited over a kiln chamber a suitable distance ahead of the fire, and is advanced from time to time as the fire progresses. Thus the source of draft is always at a fixed distance from the fire, is direct, positive and uniform, and at once effectually overcomes all the difficulties experienced with natural draft.

The kiln is built in a straight line instead of in the usual oval shape, in order to bring all the chambers properly within the range of the overhead crane, and it may be constructed on the semi-continuous principle, in which the fire is started at one end, traverses the length of the kiln and then dies out, or by the use of "return flues" connecting the two ends of the kiln, heat from the last chamber may be carried to the starting end for water-smoking purposes, as in the case of the original continuous kiln. The latter arrangement is used in the Dover Point plant.

The improved continuous kiln not only saves two-thirds of the fuel and a large part of the labor of the updraft wood-burning kiln, but produces bricks of far more uniform color with practically no cracking, breakage or other loss.

The coal for firing the kiln is brought by the crane and brick lift from the storage bin in long iron boxes,

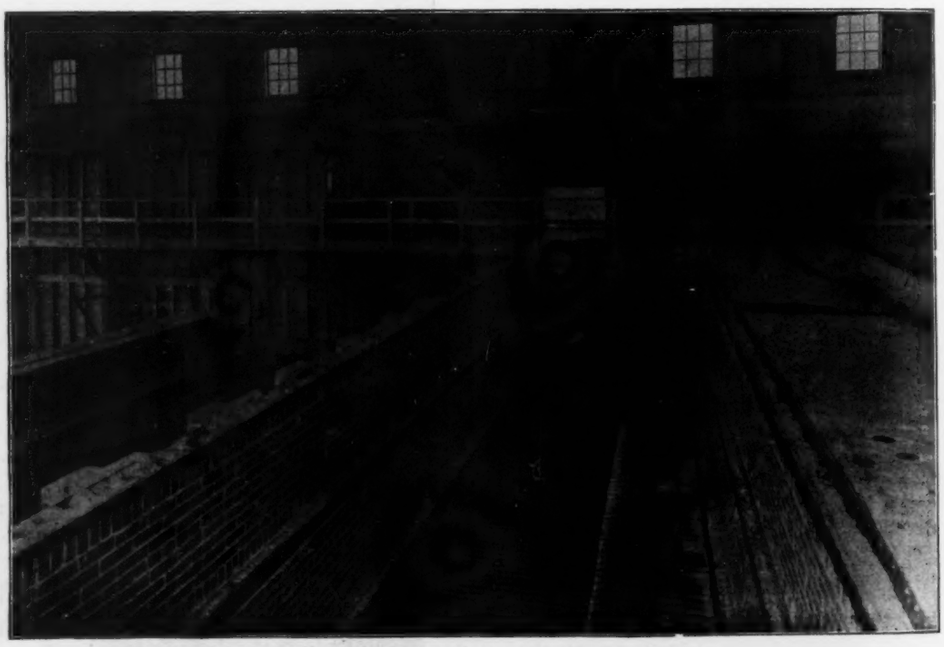


FIG. 9. VIEW LOOKING DOWN INTO DRIER CHAMBER.
(The cover and two portable racks have been removed. Two stacks of soft brick are shown in position for drying.)

which are deposited on top of the kiln adjacent to the proper feed holes. These boxes are moved along from chamber to chamber as the fire progresses. Thus the wheeling of coal is minimized and no coal is wasted by being scattered over the top of the kiln. The ashes are taken out of the kiln by a similar box, which is lowered into the chamber after the bricks are removed.

When a chamber of burned bricks has become sufficiently cooled for removal to the stock pile, the crown is lifted by the crane and brick lift and deposited over a chamber just filled with dried brick. The brick lift is then lowered into the combustion space to a proper level, the fingers are run under the stacks of burned bricks, which are lifted and transported one by one to any desired point for assorting, storage and shipment. In plants making common bricks only the bricks may be deposited upon an automatic loading machine, consisting of an endless belt with separated slats or bars for receiving the bricks, as in the case of the dryer racks, this belt conveying the bricks and dumping them into the delivery wagon, thus reducing the entire hand labor on the plant to the single operation of stacking the soft bricks at the setting-up stands. Each unit stack will fill an ordinary delivery wagon. The same device may be used to load railway cars.

FIG. 10. PORTABLE DRIER RACK SUSPENDED FROM CRANE.

In the case of the Dover Point plant, some high-grade bricks are obtained by assorting, and consequently a second-hand operation is here introduced, the burned bricks being deposited upon an assorting stand at the end of the kiln.

In the plant as thus far constructed no labor-saving appliances are used in connection with storing or loading the bricks, but it is the intention of the company to increase the main building to about twice its present length and to construct more continuous kilns similar to the one now in use. A storage building will then be constructed at right angles to the present main building, and an electric overhead crane arranged to take the bricks in large loads after assorting and to place them in the storage building, later to be shipped either by rail or water to the distant market. The elevated crane track in the storage building will be extended to include the railroad tracks at one end and the shipping dock at the other, and the assorted bricks will be handled on cradles, each containing a cart load. The cars or shipping barges may then be run under a crane at the point of destination and the cradles of bricks lifted as a unit and placed in the delivery wagons, thus eliminating the usual expense of hand labor for loading. By this system it is therefore possible to manufacture common bricks and deliver them to the customer with but two manual handlings from the clay bank to the mason, one after molding and one after burning, thus reducing the total labor to a fraction of its present amount even in the most modern yards.

The plant under discussion has so recently been put into operation that I am unfortunately unable to present any data as to the cost of manufacture, but it will doubtless be sufficient at this time to say that the practicability of the entire scheme has been fully demonstrated and that no great difficulties have been encountered. At a later date I hope to have the pleasure of presenting some data as to the cost of handling by this system and of burning in the continuous kiln with portable mechanical draft.

The preparations of the drawing and the erection of the plant has been under the immediate supervision of the consulting engineer of the company, Mr. John C. Ostrup, M. Am. Soc. C. E., well known throughout the country from his connection with the Chicago elevated roads and as designing engineer of the Boston Elevated Railroad.

FUNDAMENTAL DIFFERENCES IN THE CONSTRUCTION OF GAS AND STEAM ENGINES.

By P. Plantinga,* M. Am. Soc. M. E.

The daily increase in the use of large gas engines for operating dynamos and blowers is apparent, and manufacturers of large steam engines will soon be confronted with the question of building large gas engines according to the present styles of construction, or of originating an improved type for gas engines of great capacity.

Peculiar difficulties are met with in the construction of gas engines, which are considerably greater than most steam engine manufacturers at first imagine; and a few suggestions based on experience, which would guard against grave and expensive mistakes, may be justified.

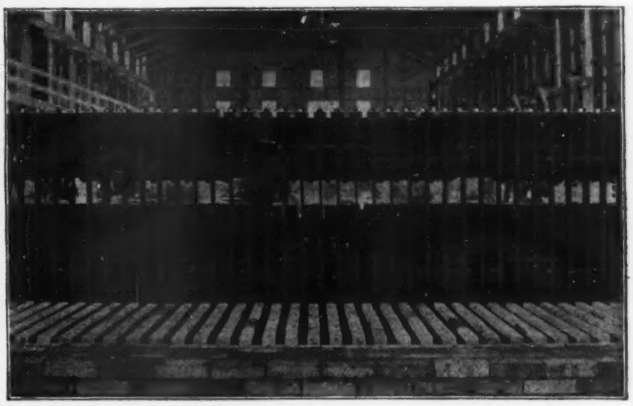


FIG. 12. BRICK LIFT DEPOSITING STACK OF BRICKS ON KILN FLOOR BLOCKS.

(This view was taken during construction of kiln and before the partition walls were built.)

At first it seems natural that the type of gas engine, which most resembles the steam engine, should excite confidence in a steam engineer. Just for this reason, Lenoir's gas engine, which was the first introduced for public use, was built as an ordinary high-pressure steam engine with valves arranged to admit gas and air and discharge the products of combustion. The intense heat on both sides of the uncooled piston was one of the causes tending to the total failure of this gas engine, built to resemble the steam engine; and it was only after Otto had built an engine which was single-acting and entirely different from a steam engine that the first enduring success was achieved.

This is not astonishing, however, since long experience in the technical world teaches that to be successful, entirely different designs and constructions must be used for radically different working conditions.

Americans owe their great success to the application of this principle—adapting all machines to their special purpose and building proportionately and consistently.

The fundamental differences in the operation of gas and steam engines all result from the main fact, i. e., that the fuel for the steam engine is burned in a separate furnace, while in the gas engine it is introduced directly and burned in the cylinder.

The cylinder of the steam engine is in no way exposed to the flame of combustion, and it is filled only with steam, which has a relatively low temperature and is a very clean medium of power. The gas engine, on the contrary, contains the combustion chamber in its cylinder, and its piston, valves and valve seats are directly exposed to the flame and very hot gases during the expansion.

The initial temperature of the steam in an engine is from about 150° to 350° C., while the initial temperature of ignition in a gas engine is about 3,000° C. The latter is therefore about 16 times as great as in a steam engine operating with 150 lbs. initial pressure, and about ten times as great as in a steam engine operating with superheated steam. The sudden pressure developed in a gas engine cylinder, amounting to from 300 to 450 lbs., and rapid expansion and fall under varying pressure to about 50 lbs., combined with the fact that

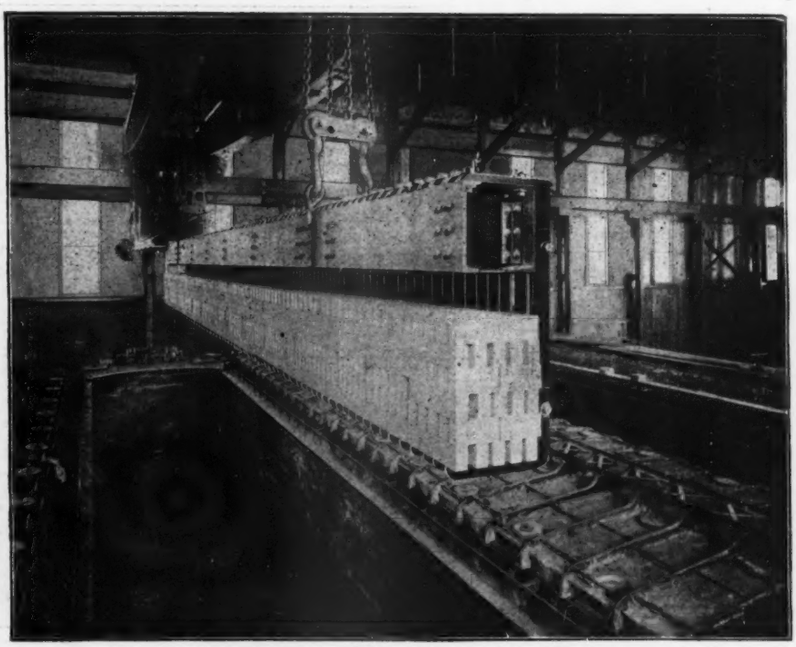


FIG. 11. KILN CHAMBER WITH CROWN REMOVED AND CRANE WITH STACK OF DRIED BRICKS READY FOR DEPOSIT IN THE KILN.

*President, The Gas Machinery Co., 720 Citizens' Building, Cleveland, O.

an impulse is not given the piston at each stroke, increases the difficulty of securing an accurate balance of the heavy reciprocating parts.

It will be seen, however, that of all of the herein-mentioned differences in construction, this one would be most easily overcome by a good designer of steam engines.

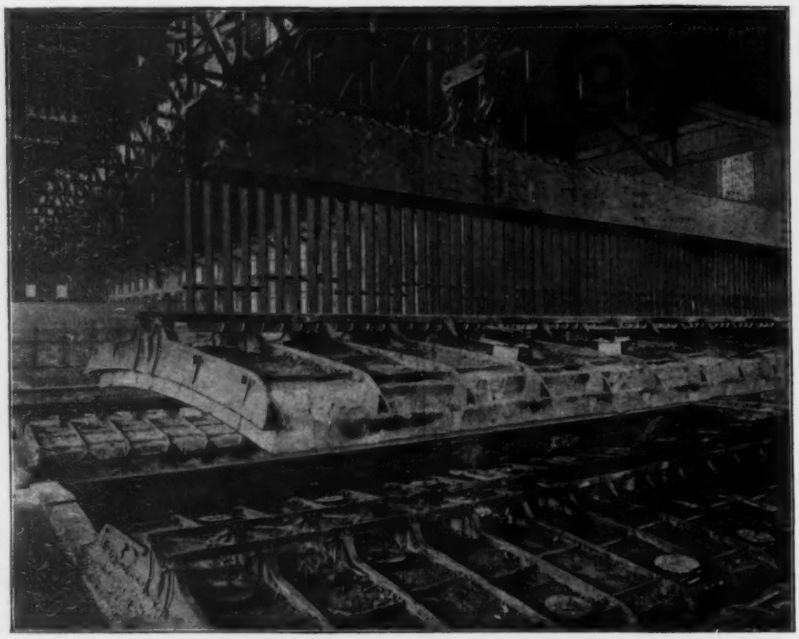


FIG. 13. REMOVABLE KILN CROWN BEING HANDLED BY CRANE AND LIFT.

The difficulty of keeping the piston tight increases greatly with the diameter of the cylinder, and is caused by the heat of the flame in the working cylinder, and the great difference in pressure on each side of the piston. This is the case even in present practice with the piston cooled by water from within; for the piston and cylinder are separately cooled, and their expansion is different.

For reasons given hereafter, dirt will easily enter the working cylinder, so that the first requirements in designing a good gas engine must be to have easy and quick access to the cylinder, particularly for engines operating continuously.

On account of the great heat, slide valves of large gas engines cannot be kept tight, and disk or poppet valves are generally used. If there is no provision for cooling, however, the heat to which these valve disks are exposed makes them red hot, as the edges become highly heated and the small surface that comes in contact with the water-cooled valve-seat is insufficient to carry off the heat on account of the short time of contact.

Several possible ways of water-cooling the valves have been used, all of which have disadvantages, and as the machine is made more complicated thereby, water leaks easily occur causing disturbances in operation. The difficulty of taking the valves apart and re-assembling them quickly when cleaning and grinding a leaky valve is increased. The cooling of gas engine valves must therefore be looked upon as an evil, even when it is considered necessary.

Duplicating exhaust valves is also being abandoned on account of complications, excess of clearance, extra cost and possibility of leaks developing, necessitating the extra work of grinding double the number of disks at regular intervals.

In steam engines operated with superheated steam it is very difficult to keep the stuffing boxes tight, and this difficulty increases so greatly with the tenfold temperature and two or three-fold tension of the burning gases in gas engines, that the number of stuffing boxes should be reduced to a minimum, as they also render easy and quick access to the cylinder more difficult.

While the steam engine cylinder is protected from loss of heat, it is important in gas engines to have good and efficient cooling of the entire cylinder; this is accomplished by means of comparatively light construction with provision for equal expansion of the walls, as cracks in the cast iron are doubly dangerous in gas engines.

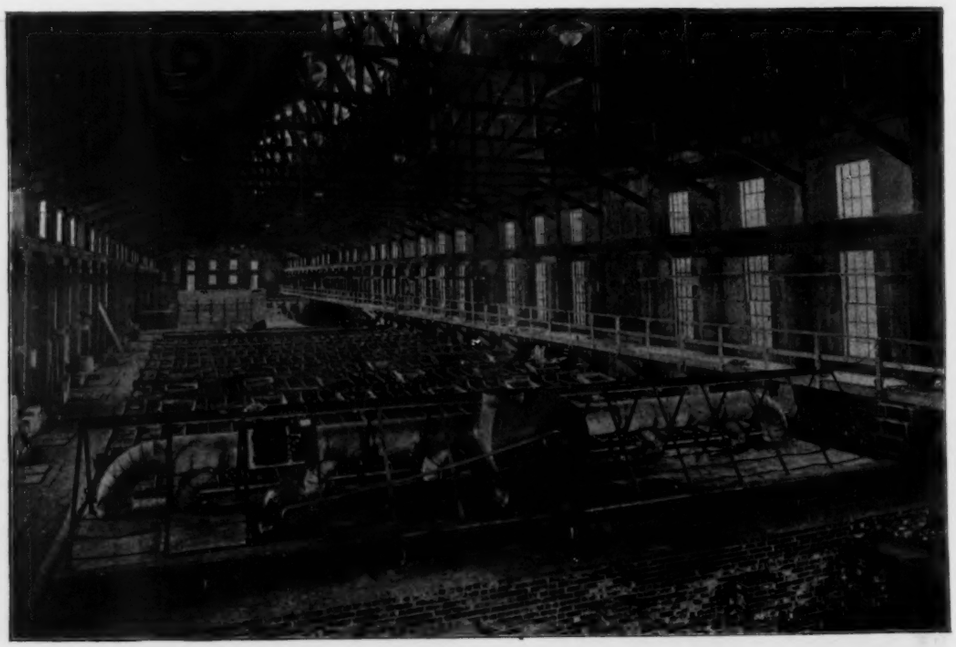


FIG. 14. PORTABLE DRAFT APPARATUS FOR KILNS.

Steam is a clean medium of power, Generator gas, however, can easily carry light particles of dust into gas engines, and even with the best methods of purification, it is well to be prepared for possible stoppage or breakdown of the purifying apparatus, especially when continuous operation must be maintained.

This again demonstrates the necessity of being able to examine and clean the cylinder as quickly as possible. Besides the dust, oil residuals, resulting from incomplete combustion, the use of poor gas, or extreme variations in the load, can easily appear, making the cylinder dirty, and causing the piston and valve to leak.

All excess of clearance space in the valve chests, ports, etc., must be avoided in the construction of a gas engine, care taken to provide for a thorough washing of the combustion chamber with fresh air after every impulse and the simplest cylindrical form used for the compression space in the working cylinder.

The requirements of a well designed gas engine are therefore the following:

1. All parts, especially the cylinder, should be easy of access. This has been emphasized by many practical builders of gas engines as much more important than a small reduction of consumption of gas per horse-power in operating.
2. In consequence of the above, the whole mechanism should be as simple as consistent, and the number of valves and stuffing boxes reduced to a minimum.
3. All excess of clearance both in and adjoining the combustion chamber is detrimental and should be avoided.
4. A thorough washing of the cylinder with fresh air should be provided after every working stroke.
5. The reciprocating parts should be balanced as well and carefully as possible.

The short foregoing sketch, which does not even touch a great number of additional structural differences respecting the distribution of the strains, etc., is sufficient to show the radical difference between the construction and operation of gas and steam engines. The elements of machine design, connecting rods, cross heads, guides, shafts, bearings, etc., which are naturally presented in the building of a gas engine, require the best experience in steam engine construction for their proper determination.

A gas engine that is most perfectly adopted to its purpose, must therefore be radically different from a steam engine in its inner construction and outward appearance, just as the successful Otto engine in its time, was in contrast to the Lenoir machine, which failed.

As shown, steam and gas engines differ widely in many respects and the inverse conclusion may be drawn, that the more the gas engine is made to resemble the steam engine in its inner construction and outward appearance, the less it is suited to its particular use and purpose.